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PHYLLOXERA-RESISTANT STOCKS

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A. GENERAL ACCOUNT

The Phylloxera is a minute insect, allied to the scales and aphids, which lives on all species of vines except *V. rotundifolia* and *V. munsoniana* of the southern states. It attacks both the leaves and roots of other American vines, but usually without doing serious injury. It attacks all vinifera varieties, usually only the roots, and finally destroys them. The only method of combating this pest that is of general application is the use of resistant vines. All resistant vines are varieties of American species, or hybrids of these species with vinifera varieties. Although the insect attacks the roots of these vines, the injury done is usually slight and not sufficient to interfere with their profitable cultivation.

I. History of the Use of Phylloxera-Resistant Stock.

(*a*) General: The Phylloxera is a native of the United States and was introduced into Europe with rooted American vines. When vines were first found to be dying under the attacks of this pest it was noted that American varieties remained apparently uninjured. This led to the planting of American vines to replace the vinifera varieties that had died. The results were disappointing. The best of the American vines weakened or died and those which survived yielded poor crops of inferior fruit.

The next step was to graft the old French vinifera varieties on to the American vines which had maintained vigorous growth in spite of the presence of the insect. The results were varied. In some instances the vines died after bearing a few crops, showing that the resistance was insufficient to maintain a vine producing heavy crops. In other

instances the vines lived, but were small and weak. In still other instances the results were satisfactory.

After fifty years of experimentation and experience, the causes of these variations are fairly well understood. It is now known that the American vines vary in their degree of resistance to Phylloxera, their adaptation to different kinds of soil, moisture, and weather conditions, the perfection and durability of the unions they make with vinifera scions, and in the vigor and fruitfulness of the vines they support.

Of the thousands of varieties which have been tested, only a few have been retained in general use. L. Ravaz, in "Les Vignes americaines," published in 1902, describes over six hundred varieties, but P. Gervais in his report to the International Congress of Viticulture in 1900 mentions only twenty-six as being largely planted. Since that time the number of varieties used widely or that can be strongly recommended has decreased.

(*b*) California: We commenced planting resistant vines in California nearly twenty years after the French and were spared much of the uncertainty of the first stages of experimentation. Owing to the great differences in soil and climate, however, we can accept the French conclusions only in a general way and as a guide for our own tests.

At first we made many of the mistakes of the French. We planted inferior and unselected stocks. We placed them indifferently in any soil and in any climate. We grafted them with any variety. And, finally, our methods of handling were usually defective. During the last fifteen years our varieties and methods have been fairly satisfactory, but there are still many instances of partial or total failure and it is probable that in but few instances are the best possible results being obtained.

II. Outline of Experiment Work.

Between 1876 and 1898 the California Agricultural Experiment Station published about 21 bulletins and leaflets on Phylloxera and resistant vines. Most of these were short and fragmentary. Since 1898 the station has given considerable attention to these subjects and has issued a number of publications. The principal are:

Bulletin 127—Bench-grafting Resistant Vines. 1900.
Bulletin 131—The Phylloxera of the Vines. 1901.
Bulletin 146—New Methods of Grafting and Budding Vines. 1902.
Bulletin 148—Resistant Vines and Their Hybrids. 1903.
Bulletin 180—Resistant Vineyards. 1906.
Bulletin 192—(In part) Insects Injurious to the Vine in California. 1907.
Bulletin 197—(In part) Phylloxera and Resistant Vines. 1908.
Circular 76—Hot-room Callusing. 1912.

These publications, which are all out of print, gave the results of experiment and observation in California and such of the results of European experience as seemed applicable to Californian conditions.

When the University acquired the Davis and Kearney farms it became possible to undertake more extended work of investigation. It seemed unnecessary and impracticable to repeat or extend most of the vast amount of experimentation that had enlightened the grape growers of Europe. It was decided to confine the work to the lines of investigation that seemed of most importance to Californian viticulture and to make as much use as possible of the previous work of European investigators by commencing where they had left off.

In the choice of varieties of stocks, the principal guide was the work of Prosper Gervais, both because of his acknowledged competence in the matter and because most of his work was done in southern France, where the conditions are in many ways similar to those of California.

(*a*) Stocks used: The stocks chosen for use in the experiment work were partly pure American species (*American stocks*), partly hybrids between two or more American species (*Americo-american stocks*), and partly hybrids between American species and vinifera varieties (*Vinifera-american stocks*).

Of the American stocks, only varieties of Rupestris and Riparia were chosen.

Varieties of *Rupestris*—the rock vine—are in a general way suited to deep soils and hot climates. They are vigorous, stout plants with fleshy, deeply plunging roots. Three varieties were used: *R. St. George, R. Martin,* and *R. Pisgah.*

Varieties of *Riparia*—the river-bank grape—are, in a general way, suited to cooler climates and rich alluvial soils, with a high water level. The best of them are vigorous, but more slender than the *Rupestris,* and they have a spreading horizontal root system. According to European experiences, they tend to increase bearing, to hasten ripening, and to improve the color, size, and sweetness of the fruit. They are more susceptible to injury from neglect and ill-treatment than the *Rupestris,* and have a tendency to be weakened or killed by overbearing. Only one variety was used, the *Riparia Gloire de Montpellier,* which is considered the best.

Varieties of *Berlandieri* have most of the good qualities of both *Rupestris* and *Riparia,* but are not generally available owing to the great difficulty of rooting the cuttings. In certain hybrids of the *Berlandieri* this difficulty does not exist and the good qualities are retained. The chief value of pure *Berlandieri* varieties is in their toler-

ance of excessive amounts of lime in the soil. As such soils are rare in California, no pure *Berlandieri* were used.

The principal Americo-american stocks used were hybrids of the three species mentioned above.

Some of the *Riparia x Rupestris* hybrids unite very successfully the good qualities of both parents. The varieties chosen were Rip. x Rup. 101–14, 3306, and 3309. The Rip. x Rup. 101–14 has more of the characteristics of the *Riparia;* the Rip. x Rup. 3309 more those of the *Rupestris;* and Rip. x. Rup. 3306 is more nearly intermediate. These varieties adapt themselves to a wider range of soil conditions than the pure species and, under most conditions, succeed as well.

Some of the *Riparia x Berlandieri* hybrids are particularly promising, doing as well as the Rip. x Rup. hybrids in a wide range of soils and doing perhaps better in dry or otherwise defective situations. Their only defect seems to be a somewhat slower development during the first two or three years. The varieties chosen were 157–11 and 420-A. The Rip. x Berl. 420-A seems on the whole to be the better and was most largely used.

Other Americo-american stocks used were the triple hybrids *Riparia-Rupestris-Cordifolia* 106–8, recommended for heavy, stiff soils, and the *Riparia-Rupestris-Candicans* 1616, recommended for saline soils. The Dogridge, a variety introduced by T. V. Munson, was used on account of its remarkable vigor. It is classed by Munson as a variety of *Vitis Champini,* but according to Ravaz the Champini varieties are hybrids of *Rupestris* and *Candicans.*

The *Vinifera-american* hybrids show a great diversity of character. Some of them bear good crops of fair fruit. These are usually insufficiently resistant. Others, generally sterile or producing fruit of little value when ungrafted, are excellent grafting stocks. They are usually vigorous, enlarging as quickly as the scion, well adapted to a large variety of soils, and rooting and grafting easily. Although a little less resistant than varieties of exclusively American origin, all that are used largely are sufficiently resistant where the soil and other conditions are favorable. The varieties of this class chosen were: Aramon x Rupestris No. 1, No. 2, and No. 9, Mourvèdre x Rupestris No. 1202, Chasselas x Berlandieri 41-B, Cabernet x Berlandieri 333 E. M., Bourrisquou x Rupestris 93-5, Tokay x Rupestris, and Lenoir (= Estivalis-Cinerea-Vinifera). The numbered hybrids are usually referred to simply by their numbers or some other contraction of their full names.

Some of these stocks are the result of the selection of vines accidentally found in the vineyard—*Rupestris St. George, Riparia gloire—*

others are the result of definite crosses made by Couderc, Millardet and de Grasset, Ganzin, Swett, and the Viticultural School of Montpellier (E. M.).

List of Stocks Used

American:

1. Rupestris St. George.
2. Rupestris Martin (Couderc).
3. Rupestris Pisgah (Bethune).
4. Riparia gloire de Montpellier.

Americo-american:

5. Riparia x Rupestris, 101–14 (Millardet and de Grasset).
6. Riparia x Rupestris, 3309 (Couderc).
7. Riparia x Rupestris, 3306 (Couderc).
8. Riparia x Berlandieri, 420-A (Millardet and de Grasset).
9. Riparia x Berlandieri, 157–11 (Couderc).
10. Riparia x Rupestris x Cordifolia, 106–8 (Millardet and de Grasset).
11. Riparia x Rupestris x Candicans, 1616 (Couderc).
12. Rupestris x Candicans, Dogridge (Munson).

Franco-american:

13. Aramon x Rupestris No. 1 (Ganzin).
14. Aramon x Rupestris No. 2 (Ganzin).
15. Aramon x Rupestris No. 9 (Ganzin).
16. Mourvèdre x Rupestris, 1202 (Couderc).
17. Chasselas x Berlandieri, 41-B (Millardet and de Grasset).
18. Cabernet x Berlandieri, 333 E. M.
19. Bourrisquou x Rupestris, 93–5.
20. Tokay x Rupestris, Swett.
21. Lenoir = Estivalis-Cinerea-Vinifera.

The following notes on these various stocks are based principally on "Les Vignes americaines," by L. Ravaz. Algerian experience is noted with some owing to the similarity of climate between that country and California.[1] In the light of our investigations, some of the opinions given in this list require modifications to suit Californian conditions.

1. *Rupestris St. George* (Syn., *R.* du Lot): This stock is used in California more than all others together. It is also used largely in France and other countries, usually under the name of *Rupestris du Lot*. It succeeds in all good soils, provided they are deep, well drained, and sufficiently supplied with water. In shallow soils, underlaid by impervious hardpan, rock, or clay, it usually fails. It is well thought of in Algeria, though it suffers in dry seasons.

[1] Vivet, E., "Compte rendu du Congrés Viticole de Montpellier," 1911.

It is very vigorous, makes good unions with most stocks, and often grows as large as the scion. Its great vigor tends to make its grafts bear lightly unless long pruned. It roots and grafts readily. It produces suckers profusely, which are very troublesome unless the cuttings are thoroughly disbudded before grafting and the vines carefully suckered during the first three or four years in the vineyard.

2. *Rupestris Martin:* This stock has most of the qualities of the *R. St. George,* but it is more difficult to graft. It is less sensitive to dryness and its grafts have less tendency to drop their fruit.

3. *Rupestris Pisgah:* When resistant vines were first used in California seedlings and cuttings from vines growing wild in the Mississippi Valley were often used. These varied very much in character and vigor, most of them being valueless. Among them occurred some especially vigorous varieties. *R. Pisgah* was of this class, and was selected by Mr. Bethune at the Mt. Pisgah Vineyard in Sonoma County. Its characters and capabilities have not yet been well tested, but it seems to be an excellent form of *Rupestris.*

4. *Riparia gloire de Montpellier:* Among the first successful resistant stocks were seedling riparias. They varied much in vigor and in general were of smaller size than the vinifera scions.

The selected variety known as the *Gloire de Montpellier* has all the good qualities of the other riparias and is superior to most of them in size and vigor. It roots easily and takes the graft well. This stock in Algeria has been short-lived except on rich, deep, moist, sedimentary soils. In other situations it has suffered during hot periods.

5. *Riparia x Rupestris 101–14:* Resembles a riparia and is best suited to rich mellow soils well supplied with water. It is distinguished from the following two by bearing fruit. The others are staminate vines and therefore bear no fruit. This stock has done well in Algeria in various soils.

6. *Riparia x Rupestris 3309:* Is the most used of the three and succeeds in soils which are too dry for the others. In Algeria it has not done well in very sandy or heavy clay soils.

7. *Riparia x Rupestris 3306:* Is said to do well in moist clay soils. It is easily distinguished from 3309 by the soft short hairiness or pubescence of its canes. It has given good results in Algeria in moist sedimentary soils.

Riparia x Berlandieri: These hybrids are the result of attempts in France to obtain a stock having the resistance to lime of the *Berlandieri* and the ease of rooting of the *Riparia.* The result is very successful.

Among these are stocks not only of high resistance to Phylloxera and to an excess of lime, but with all the other qualities we look for in a stock. They root and graft easily, improve the bearing and ripening of most varieties grafted on them, and succeed well in most soils, even in those which are too dry for the majority of stocks.

8. *Riparia x Berlandieri 420-A:* Is extremely vigorous, producing an abundance of good wood for grafting. The wood ripens well and the cuttings root and graft easily. It is easily distinguished from the following stock by the reddish or violet colored nodes of the canes and by the fact that it is staminate. This variety and 41-B have given very good results in Algeria. Their grafts are vigorous, fruitful, and resistant to drought.

9. *Riparia x Berlandieri 157–11:* Resembles the preceding in its vigor, adaptation to diverse soils, and ease of grafting. It often fails to ripen its wood thoroughly and consequently does not root so well in the nursery. This is due to its tendency to grow late in the season. Mother vines of this variety should be grown in hot dry situations.

10. *Riparia-Rupestris-Cordifolia 106–8:* Is a vigorous variety with somewhat slender canes which root easily. It is particularly suited to gravelly soils and to clay soils which become hard after the rains.

11. *Riparia x Rupestris x Candicans 1616:* Is a hybrid between *Riparia* and *Solonis* and has most resemblance to *Riparia,* being suited to about the same conditions. It is said to be very resistant to salt and might be suited to alkaline soils.

12. *Rupestris x Candicans:* A group of vines growing wild in parts of the southwestern states was named *V. Champini* by Planchon. French botanists consider these vines to be natural hybrids of *Rupestris* and *Candicans.* They are extremely vigorous plants, resistant to Phylloxera, and grow well in compact and dry soils. Most of them root with some difficulty. A variety from T. V. Munson, *Dogridge,* which seems one of the best, was tested.

13. *Aramon x Rupestris No. 1:* This is a cross between the vinifera variety Aramon and the Rupestris Ganzin. It is very vigorous and produces in abundance grafting cuttings of good size which root well. Its main defect is that many grafts fail to unite in the nursery. Those which grow, however, develop and bear well. Like most hybrids with vinifera, it is attractive to the Phylloxera, which may weaken it in poor or dry soil.

14, 15. *Aramon x Rupestris No. 2* and *A. x. R. No. 9:* These are of the same parentage as No. 1 and have very similar characteristics. They are not so much used in France, as they are more sensitive to

excess of lime in the soil. Otherwise, they are said by P. Gervais to be as good or better.

16. *Mourvèdre x Rupestris 1202:* This hybrid resembles a vinifera more than a Rupestris in its appearance, vigor, thick fleshy roots, and the ease with which it is rooted and grafted. Ungrafted, it bears large numbers of black grapes of fair size in small bunches. The Phylloxera attacks it, but does little damage in deep, moist soil. It grows as large as the scion, and its grafts are fruitful. It has given good results in moist soils in Algeria.

17. *Chasselas x Berlandieri 41-B:* This hybrid, like all crosses of Berlandieri, develops slowly at first after grafting, but finally produces vigorous, fertile vines. It will succeed in a wide variety of soils. It grafts easily, but roots with more difficulty than Riparia.

18. *Cabernet x Berlandieri 333:* This hybrid lacks almost completely the defects of the Berlandieri; that is, it roots easily and develops quickly. There seems to be some doubt as to its degree of resistance to Phylloxera, but it can be safely planted in good deep soil and it withstands drought well.

19. *Bourrisquou x Rupestris 93–5:* This vinifera hybrid is very vigorous, and easy to propagate and graft. It is resistant to drought and chlorosis and is suited to adobe soils. Like 1202, it is attacked by phylloxera, but is sufficiently vigorous to remain healthy in good soils. It bears small berries in bunches of medium size.

20. *Tokay x Rupestris No. 1:* Mr. Frank T. Swett of Martinez, California, struck with the great vigor of the Flame Tokay, which enables it to remain productive for many years after it has become infested with Phylloxera, conceived the idea of crossing it with the Rupestris St. George. He obtained a number of crosses of remarkable vigor, of which this is the most promising. It produces an abundance of grafting wood, roots easily, and takes the graft well. About its resistance to Phylloxera nothing is known, but it is probably sufficient in good soil.

21. *Lenoir:* This variety is considered by T. V. Munson to belong to the species *V. Bourquiniana,* which he has established for this plant and for the Herbemont. According to L. Ravaz, it is a hybrid of Estivalis-Cinerea and Vinifera. It is a little difficult to root, but takes the graft well and makes excellent unions. It was planted extensively in France at one time, both as a stock and as a direct producer, as it bears good crops of grapes of fair quality for wine-making. It has been abandoned almost everywhere, however, owing to its low resistance to Phylloxera, which is sufficient only in rich deep moist soils.

(*b*) Scope of the investigation: A grafting stock for vines must possess a number of qualities which concern its relation to Phylloxera, to the varieties with which it is to be grafted, and to the soil and climate in which the vineyard is situated. All these categories are variable, and no stock can be found which is best in all cases. A stock which is excellent in one set of conditions may be a failure in another. A defect which may be fatal in one case may not be of importance or may even be an advantage in another.

Our judgment of which is the best will depend to some extent on our point of view. The nurseryman is apt to consider that the best stock which will enable him most easily and most cheaply to supply his customer with large rooted grafts. To one grower, the fertility of the vines or the quickness with which they come into bearing may be of most importance. To another, the quality of the fruit or its earliness of ripening may be factors.

The investigations were planned to give data that would be useful from all points of view, and especially regarding those points which appeared of most local interest and importance.

(*c*) Equipment: The material of the experiments consisted of the twenty-one stocks already enumerated and as many as possible of the most important wine, table, and raisin grapes of California.

A collection of the chosen varieties of stocks was made and planted for the purpose of testing the methods of growing mother vines and of producing resistant cuttings for bench grafts.

A grafting house and cutting shed were built for the convenient handling, storing, and disinfection of cuttings and for experiments in grafting and callusing.

A nursery was prepared for the rooting of cuttings and grafts to be grown for the various field tests.

These field tests consisted of the growing of small plots of the various combinations of our principal grapes with the various stocks. All the vines of each variety of scion were at first treated alike as regards pruning and other operations in order that any differences found could be ascribed to the nature of the stock. As the vines developed it became necessary to modify the pruning according to the vigor of the vines, which differed with different stocks.

The various plots at Davis devoted to this work cover in all a little more than 10 acres; those at Kearney, about 3 acres. They make it possible to test the cost of producing bench grafts and the value of the various stocks from the nurseryman's point of view, viz., their relative merits as regards rooting, grafting, and development in the nursery. The value to the grape grower can also be tested, viz., the

quantity and quality of their crops, and the permanence and perfection of their unions, and therefore their longevity, and any difference which exists in these respects with different combinations of stock and scion.

Two important problems are not provided for, namely, the relative resistance of the various stocks to Phylloxera, and their adaptation to various soils. The first of these problems, however, may be considered in most cases as settled by the work and experience of European investigators. The resistance of all the varieties used may be considered as established and sufficient, except in the case of Lenoir and Tokay x Rupestris, and perhaps under unfavorable conditions for the other vinifera hybrids. The question of adaptation to various soils and climates can not of course be determined in a single location. Light on this question is to be obtained by observations in many localities. Most of the stocks used, moreover, have been proved to be well adapted to a wide range of soil conditions. Certain important climatic conditions, such as a hot and completely dry summer, are common to all the principal grape-growing regions in California.

B. EXPERIMENT DATA

I. Suitability for Nursery Purposes.

(*a*) Cost of cuttings: Resistant cuttings must be grown on mother vines planted for the purpose. Many of the best varieties for the purpose, such as R. St. George, A. x R. No. 1, A. x R. No. 2, 3306, 3309, and 420-A, are staminate and produce no fruit; others, such as 101–14 and 41-B, produce small worthless fruit. A few, such as 1202 and Lenoir, produce fair crops of small grapes which may have some value for the making of a dark red grape juice or syrup.

The amount of wood suitable for grafting that a variety will produce is therefore the main factor in the cost of the stock.

The total amount of wood produced by a vine depends partly on the variety, but principally upon the soil, climate, and cultural care. The proportion of this wood which can be used for grafting depends largely on the nature of the growth. Some varieties, like the St. George, tend to produce a large amount of small laterals which are of little use. Others, like the Rip. Gloire, produce many canes with excessively long joints, which are unsuitable. Good cuttings for grafting should be from one-third to half an inch in diameter, moderately short jointed, and thoroughly mature. The best are grown in fairly rich soil in the warmer regions, in situations safe from early autumn frosts.

The following table gives the crop of cuttings suitable for grafting produced by the original mother vines at Davis.

TABLE I

YIELD OF CUTTINGS OF VARIOUS STOCKS

	Number of No. 1 cuttings per vine				Weight per cutting in pounds			
	1915	1916	1917	Mean	1915	1916	1917	Mean
St. George	56	48	74	59	.0574	.0645	.0664	.0628
A. x R. No. 1	52	44	51	49	.0621	.0622	.0609	.0617
A. x R. No. 9	38	26	36	33	.0625	.0624	.0587	.0612
A. x R. No. 2	33	34	33	33	.0612	.0556	.0633	.0600
3306 (4)	7	16	10	11	.0437	.0353	.0431	.0407
3309 (4)	8	17	14	13	.0385	.0417	.0358	.0383
Tok. x Rup. (3)	....	....	45	....	.....	.....	.1722	.....
R. Pisgah (3)	....	....	34	....	.....	.....	.1125	.....
Champini (1) (3)	....	....	193	....	.....	.....	.0638	.....
1616 (3)	....	....	14	....	.....	.....	.0572	.....
Sol. x Othello (1) (2)	....	....	150	....	.....	.....	.0533	.....
1202 (3)	....	....	48	....	.....	.....	.0512	.....
420-A (3)	....	....	53	....	.....	.....	.0495	.....
R. Martin (3)	....	....	8	....	.....	.....	.0476	.....

(1) Vines growing in rich soil in creek bottom.
(2) Vines irrigated during summer with water from drain.
(3) Vines young.
(4) Vines near cottonwood trees and shaded.

The location where these vines were grown was not suitable for the best results. It was very uneven in soil and contour and in parts shaded by large trees. This accounts in great measure for the extreme variations in yield of different varieties. It may account also to some extent for some of the variations in growth of grafts in the nursery. The cuttings of vines grown in rich bottom soil near the creek with abundant moisture are apt to be overgrown and poorly ripened. Vines growing where the neighboring trees limited the water supply are apt to produce a small crop of cuttings.

The average product per vine is about 50 number 1 bench-graft cuttings. The small number yielded by 3306 and 3309 is due to the unfavorable conditions in which the vines are growing. The extraordinary number yielded by Champini and Sol. x Othello is due to rich soil and abundant summer irrigation.

A yield of 50 cuttings per vine represents about 30,000 per acre. If these were sold at $5 per thousand, they would yield a gross return of $150 per acre. This would be fairly profitable if there were a market for the cuttings. The cost of harvesting and preparing number 1 resistant cuttings should not exceed $2 per thousand and the cost of cultivating mother vines would be less than that of bearing vines.

The last column in Table I gives the average weight of a 15-inch cutting in pounds and indicates both the thickness and the specific gravity. The St. George is the heaviest of the common varieties, weighing 62.8 pounds per thousand. The Tokay x Rupestris and the

Rupestris Pisgah are remarkably heavy, weighing 172.2 pounds and 112.5 pounds per thousand, respectively.

Excessive size of the cuttings is not a necessary proof of superior vigor as a grafting stock. This depends as much on the vigor of the scion and the completeness of the union.

(*b*) Ease of grafting: The facility with which the mechanical operations of grafting can be accomplished depends on the size and straightness of the cuttings, the length of internodes, the size and abundance of buds and laterals, the size of the pith, the firmness of the wood, and the difficulty of disbudding.

These qualities vary with the variety and with the conditions of climate, soil, pruning, training, and cultivation under which the mother vines are grown. Some varieties, like the Riparias and 420-A, tend to grow slender, which makes it difficult to obtain cuttings large enough to fit the stouter vinifera varieties. Some, like St. George, tend to grow angled or curved canes, which are more difficult to handle in the callusing bed and the nursery. Some, like St. George and Lenoir, are short jointed, which increases the cost of disbudding; others, like the Riparias, are very long jointed, and, as it is desirable to have at least two full joints on the stock, this makes it difficult to have stocks which are not too long. Some, like St. George, easily develop dormant buds near the base of the main buds, which makes it necessary to cut deep and remove the buds very carefully to prevent undue suckering of the grafted vines in the nursery and the vineyard. This difficulty is increased where laterals are abundant, as with St. George. Where the pith is large and the wood soft, as with Riparias, it is difficult to make a perfect fit.

All these tendencies can be modified and improved by growing the vines in suitable climatic conditions and by using appropriate cultural methods.

The wood is firmer and the pith smaller where the vines are grown in the warmer regions and without too much water. The straightness of the canes can be improved and the number of laterals diminished by growing the mother vines on trellises which allow the canes to grow or to be tied up more or less vertically. The size of the canes can be increased by adopting a system of pruning which restricts the number of canes produced by a vine and by doing as little summer pruning as possible.

(*c*) Percentage and perfection of unions: The cost of bench grafts depends principally on the percentage of successful unions, their value on the perfection of the unions. In both of these respects there are

wide differences with different stocks and with different combinations of stock and scion.

Some varieties of stock are difficult to bench graft owing to their slowness in forming roots. This makes it almost impossible to make bench grafts with pure Berlandieri stocks. Such stocks can be grafted successfully only after rooting either in the nursery or in the field. Other stocks have this defect in a smaller degree, for example, Lenoir and the Berlandieri hybrids 420-A and 41-B. Where other conditions are favorable, however, these stocks can be used successfully for bench grafts, though their cost will be somewhat higher than that of more easily handled stocks.

The success of a bench graft depends not only on the variety of stock but on that of the scion and on the degree of ease with which the combination forms a union. In our tests, 420-A has yielded as high as 60 per cent of number 1 grafts with one scion and failed completely with another. Even 3309, which usually yields a high percentage, has varied under the same conditions from 88 per cent to 23 per cent with different scion varieties.

The condition of the cuttings is also of great importance. If the cuttings either of stock or of scion are defective, the results will be poor. Cuttings from vines weakened by disease or overbearing, or immature from lack of heat or premature autumn frosts, will fail. Cuttings which have been injured by keeping too wet are equally poor. There is much less danger in keeping them too dry, if the drying is not carried too far.

Finally, the work of the nurserymen is of importance. The methods of grafting, callusing, rooting, and cultivation, and the skill with which they are applied influence the number of successful unions. The soil of the nursery and its condition are also important factors.

In the tests made in these experiments, the conditions other than those of variety of stock and scion were made as uniform as possible.

Most of the cuttings, both of stock and scion, were grown at Davis, and were therefore comparable. Nearly all of the work was done by the same skilled grafter and the same nursery was used, except during the last year (1917). Comparisons between the various combinations during the same year are therefore fairly just. Comparisons between different combinations in different years are less reliable, as the condition of the cuttings varied according to the season, and after the nursery had been used for several years the results were less perfect.

For these reasons the results for 1910 are the most useful in indicating the value of the various stocks from the point of view of nursery results. If, therefore, we take the results in 1910 for varieties tested

that year and make an allowance for unfavorable conditons in the case of varieties tested only in 1916 and 1917, it may be said that the results with all varieties were excellent with the exception of A. x R. No. 2, 41-B, 420-A, and Champini, with which they were only fair. Berl. Ress. No. 2 and 157–11 and 1616 were complete failures. (See Table II.)

These remarks refer only to the average results with all scions. The variations with different scions are of even more importance. A stock whose average results are good may give very poor results with a certain scion variety and vice versa. For this reason it is important to know which stocks have given the best results with each scion variety. This information is given in Table III.

TABLE II

PERCENTAGE OF NO. 1 ROOTED GRAFTS

	1910				1916*				1917				All years
Stocks	Scions	Max.	Min.	Mean	Scions	Max.	Min.	Mean	Scions	Max.	Min.	Mean	Mean
3309	15	88	23	56.6	3	55	12	26.7	6	80	5	49.1	44.1
A. x R. No. 1	5	78	15	49.0	25	54	4	29.3	11	80	21	53.9	44.1
St. George	19	80	42	62.3	25	78	5	29.5	11	72	10	33.1	41.6
3306	18	70	22	46.5	5	44	23	30.5	8	80	20	48.6	41.4
1202	16	78	23	53.6	8	24	2	11.8	10	90	18	39.6	37.3
A. x R. No. 9	2	65	45	55.0	18	61	0	33.1	3	45	0	23.3	37.1
420-A	18	60	0	25.6	....	....	....	.....	10	80	0	40.4	33.0
Lenoir	14	82	0	40.6	....	....	....	.....	9	90	22	52.9	46.8
41-B	17	65	5	32.0	....	....	....	.....	5	70	20	39.9	36.0
Tok. x Rup.	....	....	....	.....	7	57	19	39.2	10	90	20	53.3	46.3
106–8	....	....	....	.....	1	....	....	44.4	1	....	....	35.7	40.1
Rup. Pisgah	....	....	....	.....	4	45	21	32.0	2	36	27	31.3	31.7
A. x R. No. 2	....	....	....	.....	6	57	0	32.3	2	27	17	22.0	27.2
Champini	....	....	....	.....	11	20	0	10.8	10	30	9	17.2	14.0
1616	....	....	....	.....	1	0	0	0	....	....	....	.....	0
Rup. Martin	3	80	40	58.3	....	....	....	.....	....	....	....	.....	58.3
Rip. Gloire	18	95	23	54.5	....	....	....	.....	....	....	....	.....	54.5
101–14	5	69	30	48.0	....	....	....	.....	....	....	....	.....	48.0
157–11	3	10	0	3.3	....	....	....	.....	....	....	....	.....	3.3
Berl. Res. No. 2	3	0	0	0	....	....	....	.....	....	....	....	.....	0

* The low results in 1916 were due partly to the late autumn frosts of 1915, which prevented the proper maturing of the wood, and partly to the fact that the nursery had been in constant use for too many years.

Table II gives maximum, minimum, and mean percentages of number 1 bench grafts obtained from each stock with all varieties of scions for three years.

The first six stocks in the table were tested each year with a considerable number of scions. The variations for each of these stocks with different scions are large, but the mean percentages for each stock with

all varieties (last column) do not vary greatly. This indicates that they are all good stocks, from the nurseryman's point of view, but that for the best results a careful choice of suitable combinations is necessary.

The data for the remaining stocks are less complete, but they indicate that with the exception of the pure Berlandieri, Ress. No. 2, the Berlandieri hybrid 157–11, and probably Champini, good nursery returns may be obtained from all of them with suitable scions.

The stocks which have given the best nursery results with each of the scion varieties used are shown in Table III.

TABLE III

Combinations Giving Highest Percentages of No. 1 Rooted Grafts

		Per cent		Per cent		Per cent
Palomino	St. George	72	1202	65	Rip. gloire	50
Semillon	3309	75	Lenoir	60	Rip. gloire	50
Ali. Bouschet	St. George	75	Lenoir	75	1202	63
Lagrain	St. George	70	1202	65	3306	62
Gros Mansenc	Rip. gloire	95	Lenoir	56	St. George	50
Petite Sirah	1202	78	3306	70	3309	68
St. Macaire	Rip. gloire	77	1202	75	3306	70
Valdepeñas	3309	88	Lenoir	82	Rip. gloire	75
Cornichon	St. George	45	A. x R. No. 9	45	R. Martin	40
Emperor	St. George	65	3309	65	Rip. gloire	65
Malaga	St. George	45	3306	40	1202	30
Tokay	Rip. gloire	55	St. George	50	3306	42
Black Corinth	St. George	65	Rip. gloire	61	41-B	48
White Corinth	3306	53	St. George	50	Rip. gloire	41
Muscat	3309	70	101–14	70	A. x R. No. 9	65
Sultana	A. x R. No. 1	78	1202	73	St. George	70
Sultanina	3309	85	R. Martin	80	St. George	65
Means		79.4		72.1		63.6

These tables indicate that the safest stocks for the nurseryman without special knowledge of the various combinations are Rupestris St. George, Riparia gloire, 1202, and 3309, with 3306 and Lenoir following closely. For special combinations, however, excellent results may be obtained with 101–14, A. x R. No. 1, A. x R. No. 9, and 41-B, and even with stocks which do not appear in Table III; viz., 420-A and A. x R. No. 2. Any of these varieties, therefore, may be available in special cases and should be considered in connection with their performance in the vineyard, as shown later.

(*d*) Development in the nursery: The proportion of number 1 unions obtained is of importance to the nurseryman, but the size and vigor of the grafted vines is scarcely less so. The rating in this respect of the various stocks is shown in Table IV.

It is interesting to compare these ratings of vigor in the nursery with the ratings of the same stocks after growing and bearing for

several years in the vineyard, as shown in the last column. Riparia gloire and St. George hold the last place, while 41-B retains the first place in both cases. Lenoir and 420-A have decreased in relative vigor, while A. x R. No. 1 and 1202 have increased.

It is worthy of note that R. St. George and R. Martin, which in Europe are noted for the vigor of their grafts both in vineyard and nursery, have almost the last place in this table; while 41-B and 420-A, which in Europe develop slowly at first, are here among the most vigorous.

Whether an increase in vigor in the vineyard is a good indication or not can be known only if the crop the vine has produced is also known. Other things being equal, large crops are followed by a decrease of growth, and small crops by an increase. This point will be considered later.

TABLE IV

VIGOR OF VARIOUS COMBINATIONS
(From Davis Nursery, 1917)

Stock	Number of Scion varieties	Relative vigor	
		In Nursery	In Vineyard
41-B	16	90.8	85
3306	15	88.5	77
420-A	15	88.5	76
1202	15	86.5	80
Lenoir	9	83.3	71
3309	12	81.3	76
A. x R. No. 1	5	75.0	76
R. gloire	15	68.3	65
St. George	18	65.3	70
R. Martin	4	62.5	72

II. Suitability for Vineyard Purposes.

However successfully the grafted vines may be raised in the nursery, they are of no value unless they produce the results desired by the grower in the vineyard. They must be sufficiently resistant to the attacks of the Phylloxera; they must grow well under the climatic and soil conditions of the particular vineyard; the unions must be durable and the vines relatively long-lived, and, finally, they must produce crops which are satisfactory both in quantity and quality.

The questions of resistance to Phylloxera and of adaptation to various climatic and soil conditions did not come within the scope of these investigations for reasons already given. The principal points studied were the quantity and quality of the crop and the perfection and permanence of the unions.

(*a*) Character of the unions: In order that a grafted vineyard shall give satisfactory results, a fundamental requirement is that the stock and scion shall make a good union. If the union is imperfect, the vines will be short-lived and subject to disease, and the crop will be defective in quantity and quality. Though a grafted vine is seldom as vigorous as a vine on its own roots, the crops are usually larger and of better quality when the union is good. They cannot be expected to live to the great age which ordinary vines sometimes attain and more of them will die of accidental injuries; but where the conditions are suitable and the unions good they will bear profitable crops for 20 or more years. On the other hand, the crops may be larger, the grapes sweeter, more highly colored, and earlier in ripening.

The character of the union depends on many conditions. The most fundamental is what is known as the *affinity* between the stock and the scion, that is, the durability of the union and the ease with which their respective tissues unite and with which the food streams pass from one to the other. This affinity need not be perfect. Indeed, the increased bearing, higher quality of the fruit, earlier ripening, and other advantages of many grafted vines are probably due to a moderate imperfection of affinity. The affinity, however, must be sufficient to make the vines reasonably vigorous.

Other imperfections of the union may result from unskillful grafting. Defective work may result in a failure of stock and scion to unite all around, which renders the graft liable to attack at the union by insects and decay organisms. Such grafts are liable to break off or die early, especially if the affinity is defective. Imperfect affinity may be counteracted to some extent by skillful grafting and excellent affinity may overcome to some extent the defects of unskillful grafting.

Suitable soil, water, and climate and proper cultivation and pruning also have great influence in overcoming defects of affinity or of imperfect grafting.

It was attempted in these investigations to equalize the grafting and environmental conditions, which are variable, in order to study the differences in affinity, which are constant because inherent.

Without inquiring into the exact nature and causes of affinity, we may define it as the power which stock and scion have of joining together and nourishing each other by exchange of food material. Its degree may be measured directly by the permanence of the union and by the vigor of the graft as compared to that of the stock or scion varieties ungrafted; and, inversely, by the size of the swelling which always occurs at the union, and by the difference of diameter of stem above and below the union.

All these measures, especially the first two, are influenced more or less by the environmental conditions, especially by the degree of perfection of the grafting. The size of the swelling and especially the differences of diameter are less influenced, and are therefore the best measures of affinity.

Figure 1 shows a section through the union of a five-year-old graft of Tokay on Rupestris St. George. The excellent affinity between these varieties is shown by the moderate size of the enlargement at the union, which is no greater than normally occurs at the surface of the

Fig. 1.—Defective vineyard graft of Tokay on Rupestris St. George; died when five years old.

ground on ungrafted vines. The nearness to equality of diameter of stock and scion is also a sign of close affinity. Neither of these measures of affinity has been changed much, if at all, by the imperfection of the graft which, as can be seen, was united on only one side. On the other hand, this imperfection resulted in the death of the vine at five years, probably by the work of decay organisms which obtained entrance at the unhealed grafting wound.

Figure 2 shows sections through the unions of three imperfect bench grafts just dug from the nursery. Although with care these bench grafts might develop into good vines, they run the risk of the fate of the vine shown in Fig. 1. The vine on the left (A) has united

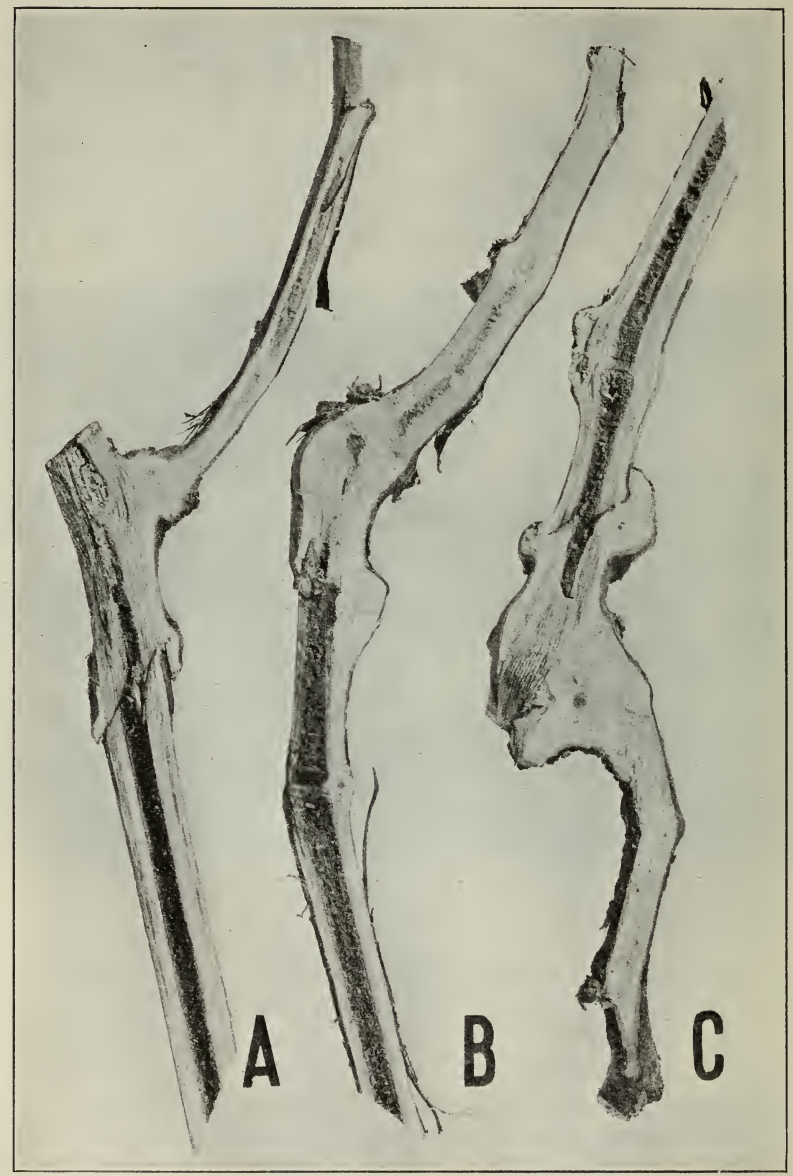

Fig. 2.—Defective bench grafts: A, Sultanina rose on A. x R. No. 1; B, Madeleine Angevine on 3306; C, Duc de Magenta on 1202.

Fig. 3.—Good bench grafts: A, Madeleine Angevine on 1202; B, Madeleine Angevine on A x R No. 1; C, Sultanina rose on Lenoir.

Fig. 4.—Unions with various stocks. Dattier de Beirut, six years old, from bench grafts.

Fig. 5.—Sections of unions shown in Fig. 4.

only in one small place and the scion has made a very small growth. The defect may be due to lack of affinity, but is just as likely to be due to defective grafting, or to unfavorable conditions in the nursery. Vine B has made a good growth and a small enlargement, which indicate an excellent degree of affinity. The graft, however, is defective because the stock is dead on one side, as shown by its dark color. Vine C[2] shows fair growth but a large swelling. The growth indicates a sufficient degree of affinity. The cause of the large swelling may be, in part at least, a defective union.

Figure 3 shows three excellent Number 1 bench grafts, though the swelling at the union of C is rather large. The affinity, so far as can be seen at this early stage, is good in all three instances.

Figure 4 shows four six-year-old Dattier vines bench grafted on four different stocks, compared with a seven-year-old ungrafted vine of the same variety. All these vines were vigorous and healthy when dug up. Judging by the size of the swelling and the ratio of the diameters of stock and scion, 420-A and 41-B show the most affinity with Dattier. The union enlargement of 41-B is almost the same as the normal enlargement of the ungrafted vine. That of 420-A is a little larger but the ratio of diameters of stock and scion shows little difference from the diameters of corresponding regions of the ungrafted vine. The other two stocks, especially 333 E. M., appear defective in these respects.

Dattier (Figs. 4, 5)	Ungrafted*	420-A	41-B	106-8	333 E. M.
Above swelling	100	100	100	100	100
Swelling	116	129	115	120	169
Below swelling	95	93	85	67	54

* The ungrafted vine was seven years old—one year older than the grafted.

The measurements are in per cent of scion diameter. The transverse white and dotted lines show limits of stock and scion.

Figure 5 shows sections through the same vines and indicates the perfection of the unions. The dark areas in the middle of each section show the original scion and stock cuttings. This is especially clear in the center vine, 41-B.

Muscat (Figs. 6, 7)	Ungrafted*	41-B	333 E. M.	420-A	106-8
Above swelling	100	100	100	100	100
Swelling	132	111	133	106	135
Below swelling	76	79	67	59	40

* The ungrafted vine was seven years old—one year older than the grafted.

The measurements are in per cent of scion diameter.

[2] This figure shows the vine upside down.

Fig. 6.—Unions with various stocks. Muscat of Alexandria, six years old.

Fig. 7.—Sections of unions shown in Fig. 6.

Figures 6 and 7 show a similar comparison of bench grafted raisin Muscats (Muscat of Alexandria). The remarkable thing about these vines is that the union enlargement is no larger than the normal enlargement with two stocks, 333 E. M. and 106-8, and considerably smaller with two others, 41-B and 420-A. The difference of diameter of stock and scion is great only with 106-8 while with 41-B it is even

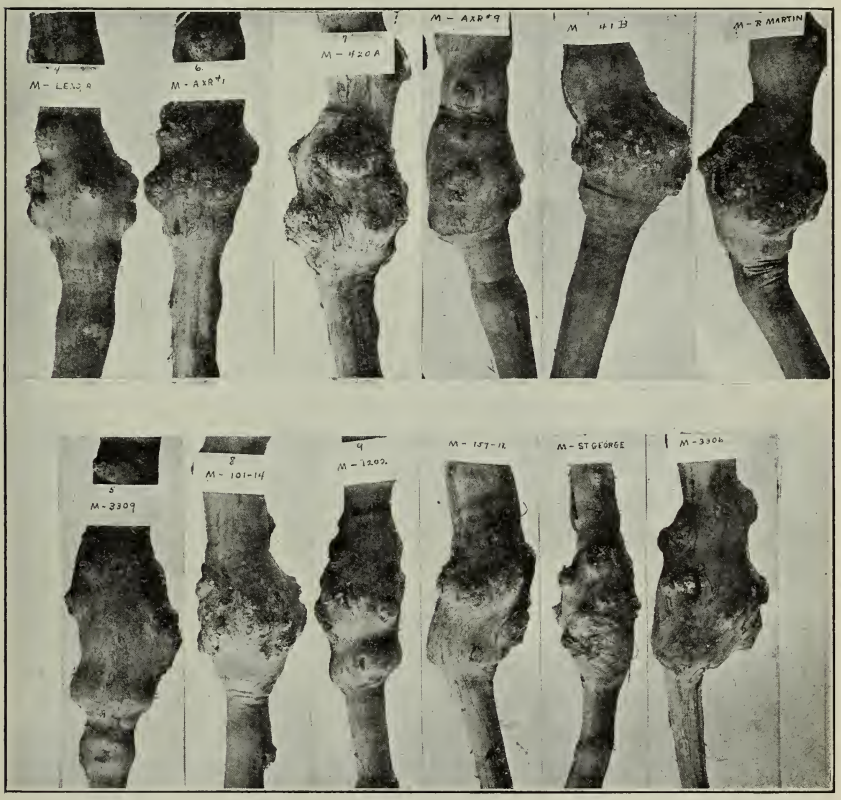

Fig. 8.—Unions with various stocks. Muscat seven years old. (Dug, measured, and photographed May, 1918.)

less than with the ungrafted vine. This last stock therefore is very promising for use with the Muscat, which is one of the most difficult to suit in this respect.

The vines shown in Fig. 8 are Muscat grafted on various stocks. They were dug up and photographed in May, 1918, the seventh spring after they were planted. The unions are all excellent but show varying degrees of inequality between diameters of stock and scion and various developments of the graft enlargement. These enlargements are all greater than those of the Muscats shown in Fig. 6. It is

probable that the size of the enlargements is influenced by the number of suckers which grow near the union and by the time and manner of removal of these suckers. For this reason the size of the enlargement in old vines is of less importance than the difference between the size of stock and scion in determining the suitability of a combination.

Stock (Fig. 8)	Circumference in cm.			Ratios, Scion = 100	
	Stock	Union	Scion	Union: Scion	Stock: Scion
Lenoir	13.7	28.0	15.9	176	86
A. x R. No. 1	12.5	26.9	15.7	171	80
420-A	12.0	32.2	15.8	204	76
A. x R. No. 9	11.9	24.9	17.2	145	69
41-B	11.7	29.0	15.1	192	78
R. Martin	11.6	30.2	17.9	168	65
3309	11.2	28.7	16.9	170	66
101–14	10.8	28.4	16.8	169	64
1202	9.5	22.7	12.4	181	77
157–11	9.0	26.7	17.3	154	52
St. George	8.6	21.2	11.4	186	75
3306	7.9	25.1	14.6	172	54
Means	10.8	27.0	15.5	172.3	70.1

Judging by the size of the stock and the stock scion ratio, Lenoir and A. x R. No. 1 seem the best stocks for Muscat. These are the stocks which are most used for Muscat in South Africa. Lenoir should be excluded, however, on account of its inferior resistance to Phylloxera. The six stocks in the first row are all good in both respects. The last four in the second row show a poor growth of stock, and 157-11 and 3306 a great overgrowth of the scion. St. George and 1202, two of the most vigorous stocks when ungrafted, have produced the smallest scion growth, and, with the exception of 3306, the smallest stock growth. The sufficiency of the affinity of these four for Muscat is therefore doubtful.

The photographs and measurements of the vines shown in Figs. 8, 9, and 10 are only single instances of each combination and as individual grafted vines differ as do ungrafted vines, averages of a number of grafted vines of each combination are a better basis for judgment. Such averages will be given later.

Stock (Fig. 9)	Circumference in cm.			Ratios, Scion = 100	
	Stock	Union	Scion	Union: Scion	Stock: Scion
1202	15.0	24.7	22.3	111	67
A. x R. No. 1	15.0	35.0	28.0	125	54
420-A	14.6	25.9	19.0	136	77
3306	14.2	28.4	24.0	117	64
Lenoir	14.0	31.5	20.8	151	67
R. Martin	13.3	22.0	16.0	138	83
101–14	12.5	27.3	18.3	149	68
R. gloire	9.7	20.5	15.0	137	65
St. George	9.5	15.2	13.5	113	70
Means	13.08	25.6	19.6	130.7	68.3

The vines shown in Figure 9 are Sultanina grafted on various stocks. Judging by the size of the stock they are all good for this scion except R. gloire and St. George. A. x R. No. 1 shows a very large growth of scion without a correspondingly large growth of stock.

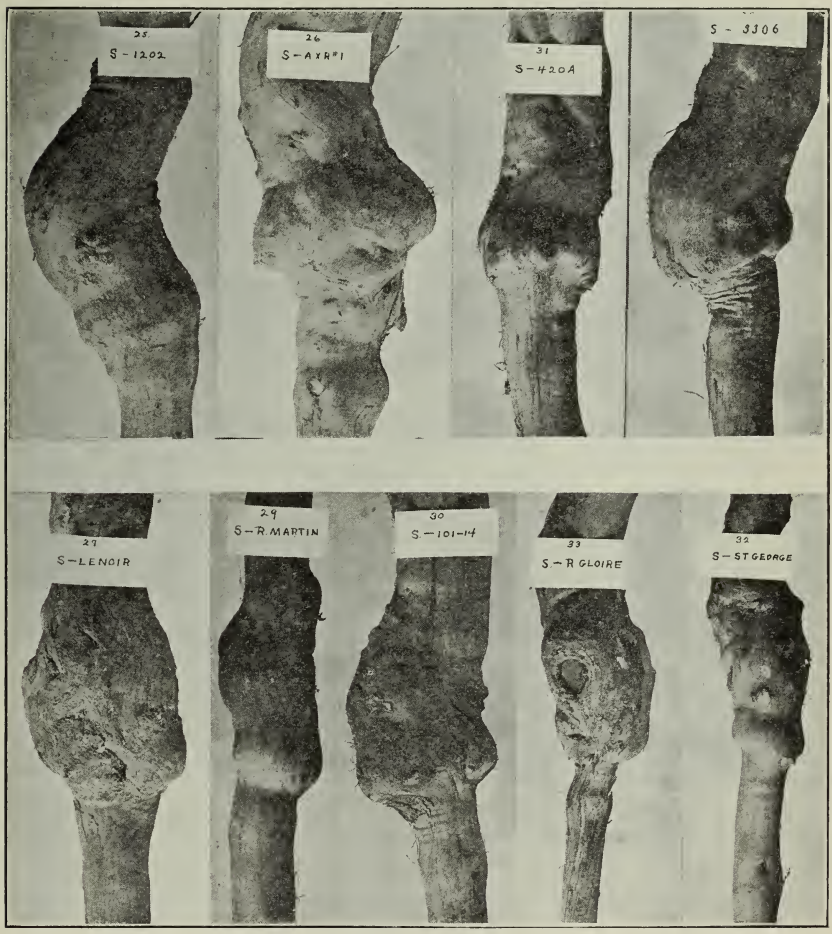

Fig. 9.—Unions with various stocks. Sultanina, seven years old. (Dug, measured and photographed May, 1918.)

The ratings of Cornichon shown in Fig. 10 are all good and it would be hard to choose among the first five.

All the grafted vines at Davis were measured in 1914 after they had grown four years in the vineyard. Table V shows the stock scion ratios calculated from these measurements.

The ratios for all the stocks which are not starred are the results of actual measurement of five to fifteen vines of each combination and the mean ratio for each stock and for each scion is based on measurements of grafts with the same seven scion or stock varieties. Some

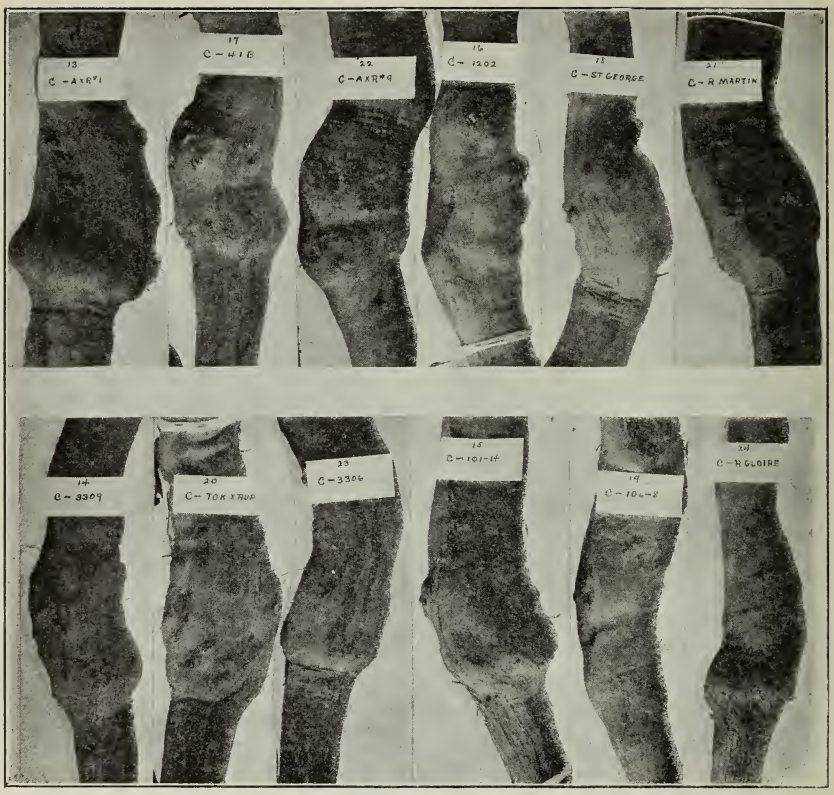

Fig. 10.—Unions with various stocks. Cornichon, seven years old. (Dug, measured, and photographed May, 1918.)

Stock (Fig. 10)	Circumference in cm.			Ratios, Scion = 100	
	Stock	Union	Scion	Union: Scion	Stock: Scion
A. x R. No. 1	21.7	34.1	22.9	149	95
41-B	18.2	26.4	21.7	122	83
A. x R. No. 9	17.0	26.5	21.4	124	79
1202	17.0	23.6	17.8	133	96
St. George	16.9	25.0	18.7	134	90
R. Martin	16.8	25.9	21.7	119	77
3309	15.7	25.6	20.0	128	79
Tok. x Rup.	15.3	26.4	20.9	126	73
3306	14.5	24.6	22.0	112	66
101–14	13.6	25.9	19.5	133	69
R. gloire	12.1	21.5	16.1	134	75
Means	16.2	25.8	20.2	128.5	80.1

stocks were not grafted with all of these scions and the mean ratio given is the result of a calculated correction for this fact. The figures must not be taken as absolute, therefore, but only as showing in a general way the tendency of each stock and each scion. All they show is that, as a general rule, the varieties either of stock or scion near the top of the table usually show a small difference between stock and scion diameters, and those near the bottom usually show a large difference. They are useful in choosing a stock for general use or for scion varieties whose preferences are not known. Ratios for each variety for each stock will be given later so far as observations have been made.

TABLE V

AVERAGE STOCK: SCION RATIO OF EACH STOCK AND SCION

Each Stock with All Scions			Each Scion with All Stocks		
Stock	Number of Scions	Ratio	Scion	Number of Stocks	Ratio
1202	15	96.3	St. Macaire	7	97.4
*Lenoir	8	95.1	*Corinth, Black	3	94.4
*R. Martin	3	94.0	Sultana	8	94.3
St. George	17	92.2	Gros Mansenc	7	93.9
41-B	14	90.8	Lagrain	8	92.9
420-A	14	89.9	Sirah	7	91.5
*101–14	4	86.7	Cornichon	8	90.4
*A. x R. No. 9	2	83.2	Tokay	7	89.3
Rip. Gloire	16	82.0	*Corinth, White	2	88.3
3309	14	80.7	Emperor	8	88.1
3306	16	77.8	Palomino	7	86.2
*A. x R. No. 1	5	76.4	Muscat	8	85.3
*157–11	1	62.1	Valdepeñas	8	85.1
			*Semillon	6	83.5
			Malaga	8	82.4
			Beba	7	80.2
			Sultanina	7	74.1
* Ratio calculated.			*Bouschet, Ali	6	73.8

(*b*) Vigor of the bearing vines: The grafted vines at Davis were carefully examined when they were five years old. Notes were taken on their apparent vigor, the length and thickness of canes, and their general appearance of thrift and health. None of these characters are capable of an exact numerical evaluation, and therefore, the following scale of grades based on examination was used:

Very poor	= 1
Poor	= 2
Medium	= 3
Good	= 4
Very good	= 5
Exceptionally good	= 6

A summary of the results for each stock, reduced to a scale of 100= exceptionally good, is given in Table VI. This table is based on

observations of only one year and with a few stocks of only one or two grafting combinations. For the cases where the stock has been grafted with a considerable number of scions it is of considerable value.

It is instructive to compare these results with the notes on vigor in the nursery (see page 97). In both cases, 41-B holds the first rank and St. George almost the last rank. In the nursery, 1202 was vigorous and increased in relative vigor in the vineyard. R. Martin, which was weak in the nursery, was somewhat more vigorous in the vineyard. Lenoir, which was fairly vigorous in the nursery, was among the weakest in the vineyard. Riparia gloire showed weakness in the nursery and was still worse in the vineyard. The rank of the other stocks was about the same in nursery and vineyard, 3306, 420-A, being vigorous, and 3309 and A. x R. No. 1 of fair vigor in both.

These remarks refer only to averages. As will be seen later, there are important exceptions. Some stocks which give vigorous vines with most scions give poor growth with others, and vice versa.

TABLE VI

Relative Vigor of Grafts on Various Stocks

Stock	Number of scion varieties	Relative vigor
41-B	13	85
1202	14	80
3306	15	77
420-A	15	76
3309	13	76
A. x R. No. 1	6	76
Lenoir	9	71
St. George	15	70
R. gloire	14	65
333 E. M.	1	83
R. Martin	4	72
93–5	1	72
A. x R. No. 9	2	71
101–14	4	68
157–11	1	68

(*c*) Durability of the vines: In all vineyards, whether grafted or not, vines die occasionally. The causes of death are varied. Some receive severe injuries in cultivation, some become infected by wood-destroying fungi obtaining entrance through wounds, and some are killed by frost, over-bearing, drought, or the combined effect of several minor weakening causes. Leaving out of consideration serious diseases and pests which may destroy many or all the vines, there are always present numerous unfavorable or injurious conditions which will result in the destruction of a smaller or larger number of the vines in any vineyard. How large a percentage of the vines will die each

year on the average depends on the natural vigor of the vines, on the more or less favorable environmental conditions, and on the care and skill of the grower. Under the most favorable circumstances, the number of vines which die in a grafted vineyard will be equal to the number which die in an ungrafted one and usually it will be greater.

The number which die the year of planting varies greatly according to the quality of the vines planted and to the care used in planting and cultivating them, and is not a good criterion of the permanence of the vines when they are once well established.

A "stand" of anything over 90 per cent at the end of the first year may be considered good in any vineyard. In a demonstration vineyard of 40 acres at Kearney, a stand of 96 per cent was obtained the first year with ungrafted Muscats and 93.1 per cent with ungrafted Sultanina. With Sultanina grafted on various stocks an average stand of 90.8 per cent was obtained in the same vineyard. The variations of stand with various stocks is shown in Table VII.

TABLE VII

STAND OF GRAFTED SULTANINA
(Kearney Demonstration Vineyard)

Stock	Vines planted 1918	Vines growing 1919	Stand, per cent
R. Pisgah	33	33	100.0
Lenoir	57	58	98.2
Tok. x Rup.	85	81	95.3
3306	670	629	93.9
3309	1,132	1,062	93.8
1202	56	51	91.1
A. x R. No. 9	78	70	89.7
St. George	58	50	86.2
420-A	200	168	84.0
A. x R. No. 2	85	68	80.0
Champini	18	14	77.8
41-B	114	81	71.0
A. x R. No. 1	99	66	66.7
Totals and Mean	2,685	2,429	90.8
Ungrafted	5,799	5,399	93.1

The stand of all the first seven stocks is good to excellent, averaging 97 per cent, which is better than that of the ungrafted vines. The stand of the last five stocks is only fair.

Stands of Sultanina, Muscat, Black Corinth, and Ohanez in the Experiment Vineyard at Kearney are shown in Table VIII.

A high stand of St. George is shown with all the varieties shown in Table VIII. With Sultanina, 3309 is also good; with Muscat, 3309, 93-5, and Tokay x Rupestris; with Black Corinth, 3306; and with Ohanez, 3309. Too much weight should not be given to poorer results

of some of the combinations shown because they are special instances and may represent defective cuttings used in grafting, or defective work or bad conditions in the vineyard. The durability of the vines after the first year is of more importance and will be discussed later.

The durability of grafted vines is influenced both by the stock and the scion. Certain scions varieties like the Muscat and the Alicante

TABLE VIII

STAND OF GRAFTED VINES
(Kearney Experiment Vineyard)

Scion	Stock	Vines planted 1916	Vines growing 1917	Stand, per cent
Sultanina	St. George	24	21	87.5
Sultanina	3309	28	23	82.2
Sultanina	3306	24	14	58.3
Sultanina	420-A	6	2	33.3
Muscat	St. George	118	115	97.5
Muscat	3309	166	159	95.8
Muscat	93–5	24	22	91.7
Muscat	Tok. x Rup.	10	9	90.0
Muscat	101–14	....	3	.....
Muscat	A. x R. No. 1	17	13	77.0
Muscat	333 E. M.	....	22	.....
Muscat	A. x R. No. 2	12	8	66.7
Muscat	106–8	....	6	.....
Muscat	A. x R. No. 9	22	11	50.0
Muscat	420-A	....	33	.....
Black Corinth	3306	24	23	95.8
Black Corinth	St. George	77	73	94.8
Black Corinth	A. x R. No. 1	91	75	82.4
Black Corinth	3309	12	8	66.7
Ohanez	St. George	24	24	100.0
Ohanez	3309	24	21	87.5
Totals and Means		703	621	88.3

Bouschet tend to be short-lived on most stocks, while others like the Palomino tend to be durable on most. The same differences exist between stocks. In Tables IX, X, and XI the durability of the grafted vines is indicated in the column headed "Death rate." The death rate represents the mean percentage of vines dying each year after the first. It is calculated on six years in the first two tables and on five years in Table XI.

Table IX shows the percentage of living vines growing in vineyard Number 1 at Davis in 1912 and in 1917. These vines were planted in 1911 so that the percentage growing in 1912 represents the "stand" and that growing in 1917 the "durability." A loss of over 2 per cent after the first year is considered excessive. Of all the stocks grafted with 10 or more scion varieties, only Rip. x Rup. 3309 and 420-A and

41-B keep within the limit of 2 per cent. These figures, however, are based on all combinations. With some combinations the loss was less than 2 per cent, with others more. By a careful adaptation of stock to scion a combination can usually be found where the loss will not be excessive.

With some scion varieties this is more easily accomplished than with others, as can be seen by reference to the second part of Table IX, where the scion varieties are compared. With the first 9 varieties the

TABLE IX

DURABILITY OF GRAFTED VINES

Davis Experiment Vineyard (Summaries)

	Number of vines planted, 1911	Number of varieties	Per cent growing 1912 (stand†)	Per cent growing 1917	Death rate,* loss per cent per year
Stocks compared:		Scions			
3309	183	14	81.4	72.1	1.9
420-A	137	15	95.6	83.9	2.0
41-B	181	16	83.4	71.3	2.4
3306	210	17	85.2	70.5	2.9
Riparia Gloire	230	16	77.0	62.2	3.2
St. George	288	21	75.7	60.4	3.4
A. x R. No. 1	94	6	91.5	72.3	3.5
1202	206	16	91.8	69.1	4.1
Lenoir	124	10	87.1	63.7	4.5
157–11	2	1	100.0	100.0	0.0
101–14	53	4	90.6	90.6	0.0
R. Martin	34	4	85.3	82.4	0.6
93–5	36	1	91.7	80.6	2.0
A. x R. No. 9	43	3	100.0	67.4	5.4
333 E. M.	12	1	91.7	50.0	7.6
Scions compared:		Stocks			
Sultanina	87	9	94.2	94.2	0.0
Lagrain	94	8	74.5	71.3	0.7
Palomino	77	7	88.3	84.4	0.7
Sultana	96	8	94.8	90.6	0.7
St. Macaire	118	7	60.2	56.8	0.9
Petite Sirah	96	8	96.9	90.6	1.1
Emperor	66	9	89.4	81.8	1.4
Malaga	74	8	95.9	86.5	1.7
Gros Mansenc	106	8	54.7	48.1	2.0
Semillon	88	7	82.9	69.3	2.7
Dattier	108	5	92.6	76.8	2.8
Cornichon	55	10	94.5	78.0	2.9
Muscat	153	12	93.5	74.5	3.4
Valdepeñas	168	8	76.8	58.9	3.9
Alicante Bouschet	110	7	89.0	54.5	6.4
Beba	70	6	97.1	58.8	6.6
Tokay	96	8	95.8	55.2	7.1
Pierce	11	1	100.0	100.0	0.0
Black Corinth	47	3	91.5	87.2	0.8
White Corinth	24	2	87.5	79.2	1.6
Flame Muscat	24	1	54.2	45.8	2.6
Alicante Ganzin	5	1	80.0	40.0	8.3

* Death rate = the mean percentage of vines dying each year after the first.

† Stand = the percentage of vines living at the end of the first year.

average loss with all stocks does not exceed 2 per cent annually, while with the 13th to the 17th it exceeds 3 per cent, rising to over 7 per cent in the case of Tokay.

In Table X, page 131, the record is shown of each scion variety with each stock on which it was grafted at Davis and in Table XI, page 135, the same data for Kearney.

(*d*) Quantity of crop: The amount of grapes produced by a vine depends on a large number of factors—soil, climate, method of pruning, etc.,—of which the relation of stock and scion is but one.

To determine the effect of this factor we must separate it in some way from the effects of all others. We have attempted to do this by growing the grafted vines which we wish to compare in a piece of apparently uniform soil and by treating them with identical methods. With all possible care, in this way differences due to the factors we wish to eliminate are lessened but cannot be removed entirely.

The reason of this is that we cannot be sure that the particular soil where one vine is growing is exactly like the particular soil where another is growing, nor that the treatment received by one vine is exactly the same as the treatment received by another.

We cannot therefore base an opinion on single crops of single vines. We may assume, however, that if we have taken all practicable care to equalize conditions, the unavoidable inequalities will be distributed sporadically through time and space. We may therefore give considerable weight to observations made on several vines of each class and continued over a series of years.

This is illustrated by the record of 72 ungrafted Muscat vines growing in the Experiment Vineyard at Kearney, on a piece of apparently uniform soil and treated as nearly alike as possible. The crop of each vine has been weighed each year for four years.

The record shows that the smallest single crop of a single vine was 11 pounds and the largest 65 pounds, a variation of 100 to 591. If these two vines had been grafted on different stocks, any difference of crop due to the stocks could not have been distinguished in the presence of the enormous difference due to other factors. Single crops of single grafted vines therefore are of little value in determining the suitability of a combination. A large crop is evidence favorable to the stock used, but gives no evidence as to the relation of one stock to another, while a small crop gives no evidence at all.

If we segregate these same Muscat vines into three groups corresponding to three rows of 24 vines each, we find that the smallest mean crop per vine for a group in one year was 25 pounds and the largest 32 pounds, a variation of 100 to 128. This indicates very

clearly that the variations due to uncontrolled factors have been measurably equalized by the use of groups of 24 vines. This difference of 28 per cent, however, is still large and would mask smaller differences caused by differences of grafting stock. Differences of 50 to 100 per cent which we have found in groups of vines grafted on different stocks might, however, be distinguishable.

The variations due to uncontrolled factors can be still further equalized by considering the mean crops of the groups for a term of years. The mean crop per vine per year for each of the three groups of Muscat vines for four consecutive years varied from 28 pounds to 31 pounds, a variation of 100 to 111.

The extreme variation, then, between crops of single ungrafted vines in single years was as 100 : 591; between groups of 24 vines in single years, as 100 : 128; and between groups of 24 vines for a term of four years as 100 : 111.

The crop ratings of the grafted vines have been based on the record of groups for four years. It seems safe to conclude, therefore, that variations of 10 to 15 in the hundred have no significance, but that greater variations indicate the effects of the different combinations of stock and scion.

The data on which conclusions have been based are given in Tables XII (page 136) and XIII (page 139).

(e) Quality of crop: The effect of the stock on the quality or character of the fruit of the scion has been a matter of controversy, but there seems to be no evidence of value that the nature of the stock has any influence whatever on the specific or varietal characters of the scion. If a white grape is grafted on a red-fruited stock the fruit of the scion will have no more tendency to be red than if it were grafted on a white-fruited stock or were growing on its own roots. There is just as much probability that a scion variety will bear well if grafted on a light-bearing stock as if grafted on a heavy-bearing one. A vine grafted on a staminate or male stock, which can bear no fruit, may be just as fruitful as if grafted on a pistillate or fruit-bearing stock.

This does not mean that the stock is without influence on either the quality or the quantity of the scion which it supports. There is convincing evidence that it has great influence on both. But so have soil, cultivation, climate, and many other conditions.

This influence seems confined to qualities which depend on the kind and amount of nutritive material which the scion receives. We cannot give a Muscat flavor to a Malaga vine, nor a Concord flavor to a Corni-

chon, by any method of pruning, irrigation, or fertilization, nor can we accomplish this object by grafting on to a Muscat or a Concord stock. By modifications of the soil, climate, and cultural conditions, however, we can increase or diminish the crops of a Malaga or a Cornichon, we can modify the time of ripening, the size of the berry, the sweetness and acidity, and even the *amount,* though not the *kind,* of color and flavor. The differences found between grafted and ungrafted vines and between vines grafted on different stocks, then, are due to differences of nutrition.

An attempt has been made in the last section to evaluate the influence of the stock on the quantity of the crop. It is more difficult to estimate the influence on the quality.

The quality of a grape is determined by numerous factors, sugar, flavor, color, texture, size. Most of these factors vary in the same direction with the same changes of conditions. For example, if a vine is badly nourished the fruit will usually lack sugar, flavor, size, and color, it will be of inferior texture, and ripen imperfectly. By determining one of these characteristics, therefore, we have to some extent a measure of all. The characteristic most easily measured is that of the sugar content of the juice.

With table grapes this measure is not completely satisfactory. The size, color, and texture of the fruit vary more or less independently of the sugar content and are even more important. However, in establishing legal standards for shipping grapes, the sugar content is the main reliance even with this type of grape. With raisin, grape juice, and wine grapes it is in most cases quite reliable, especially when the comparisons are made between grapes growing in the same vineyard or region.

TABLE XIV

Average Balling Degree with Each Stock
(Davis, 1919)

Stocks	Number of scions	Balling degrees		
		Maximum	Minimum	Average
St. George	18	35.0	17.5	26.1
Riparia Gloire	15	36.4	17.8	25.7
3306	16	30.4	18.6	25.6
420-A	14	28.7	19.5	24.5
1202	14	28.8	18.1	24.4
A. x R. No. 1	7	28.6	18.6	24.1
3309	13	27.2	19.0	23.8
Lenoir	9	28.4	20.5	23.6
41-B	13	30.6	18.6	23.3
101–14	4	28.6	19.7	26.2
A. x R. No. 9	3	28.4	20.0	25.4
157–11	1	24.8	24.8	24.8
93–5	2	23.9	22.5	23.2
R. Martin	4	28.0	17.5	22.9
333 E. M.	1	21.0	21.0	21.0
Tokay x Rupestris	1	20.3	20.3	20.3

TABLE XV

Average Balling Degree with Each Scion
(1915, 1916, 1917, Davis)

Scions	Number of stocks	Balling degrees		
		Maximum	Minimum	Average
Palomino	7	26.5	24.1	25.4
Semillon	7	27.0	25.5	25.4
Alicante Bouschet	7	23.9	21.6	22.6
Lagrain	8	26.6	24.0	25.2
Gros Mansenc	8	27.2	25.7	26.4
Petite Sirah	8	24.8	21.9	23.0
St. Macaire	7	25.5	23.3	24.5
Valdepeñas	8	28.8	25.6	26.8
Cornichon	12	18.7	17.5	18.2
Dattier de Beirut	6	22.7	20.0	21.8
Emperor	9	20.3	17.7	18.5
Malaga	8	23.0	20.3	22.1
Tokay	8	23.0	20.5	21.6
Muscat	12	28.2	23.2	25.5
Sultana	8	23.2	20.6	22.3
Sultanina	9	26.4	24.2	25.0
Muscat, Flame	1	.....	.....	25.0
Corinth, Black	3	31.1	26.0	29.0
Corinth, White	2	29.8	27.7	28.8
Pierce	2	21.7	21.5	21.6
Alicante Ganzin	1	.....	.....	22.0

In Table XIV the stocks are arranged in the order of the average sugar content of the crops of the various scion varieties grafted on them. In a general way, the ranking according to sugar content is the reverse of the ranking according to amount of crop. (See Tables XVIII to XXXV.) For example, the scions on St. George produced as a rule the sweetest grapes but the smallest crops. The crops of scions on Lenoir and 1202, however, were often both small and of low sugar content.

While the sugar content is a fairly accurate measure of the quality of two samples of grapes it is not an easy measure to apply in the estimation of the value of different stocks. The reason of this is that the stocks influence also the amount of crop and the time of ripening. If therefore we find that the grapes on one stock are sweeter than those on another we may not be sure whether this is due to a difference in time of ripening, to a difference in amount of crop, or to some other difference. If the grapes on one stock are sweeter than those on another, it may simply indicate that the first stock promotes early ripening. The second stock may produce grapes of equal sweetness and general quality if given time. Moreover, smaller crops are usually sweeter, so that whether higher sugar content represents a gain can be determined only when we know the crop that accompanies it. After making allowance for these uncertainties, however, we can say that a higher sugar content is a favorable indication whether it represents simply earlier ripening or a partial compensation for smaller crops. With raisin grapes and grapes used for juice or syrup the product obtained by multiplying the crop per vine by the sugar per cent is a means of calculating the sugar per acre which will give a close approximation to the comparative value of the crop.

In order to compare the different stocks in this way the average crop and average sugar (Bal. °) of each stock with all scions is shown in Table XVI.

The last column in Table XVI represents the pounds of sugar or solid contents yielded by 100 vines and is convenient for comparison, though it makes little change from the order of stocks obtained by arranging them according to yield of grapes.

An element of uncertainty is introduced into this table by the fact that each stock was not grafted with exactly the same set of scion varieties. This inaccuracy is probably great in the cases of stocks with which a small number of scion varieties was used. For this reason the stocks representing less than five scion varieties have been segregated at the bottom of the table.

An attempt has been made to obtain a more accurate comparison in Table XVII. In this table, the principal stocks have been compared in respect to only those ten scion varieties on which each and all were grafted. These are Tokay, Malaga, Palomino, Semillon, Alicante Bouschet, Petite Sirah, St. Macaire, Valdepeñas, Lagrain, and Gros Mansenc. A. x R. No. 1 was grafted with only five of these scions and Lenoir with only six. In these cases, the ratings have been computed by comparing their records with all scions used, with the record of St. George with the same scions, and correcting for the ten scions used for the other stocks.

TABLE XVI

RELATIVE BEARING AND SUGAR CONTENT

(All stocks and all scions, 1915, 1916, 1917)

Stock	Number of combinations	Average crop, pounds per vine	Average Balling degree	Crop x Balling
A. x R. No. 1	6	30.1	21.4	644
420-A	15	27.2	23.2	642
3309	13	26.4	23.6	623
41-B	15	25.6	23.1	591
3306	16	23.0	24.3	559
Lenoir	9	21.7	23.1	501
Riparia Gloire	15	20.1	24.7	496
1202	15	18.9	23.4	442
St. George	20	12.2	24.8	303
Tok. x Rup.	2	32.1	20.0	642
157–11	1	22.5	26.1	587
101–14	4	25.3	22.7	574
93–5	2	20.0	23.2	464
A. x R. No. 9	3	21.2	21.8	462
R. Martin	4	20.7	22.3	462
333 E. M.	1	14.9	20.0	298
106–8	1	16.3	17.5	285

TABLE XVII

RELATIVE BEARING AND SUGAR CONTENT

(Ten identical scions on each stock, 1915, 1916, 1917)

Stock	Average crop, pounds per vine	Average Balling per cent	Crop x Balling
420-A	29.6	23.6	699
41–B	25.8	23.6	609
3309	24.4	24.4	595
A. x R. No. 1	21.9	26.0	569
3306	22.4	24.9	568
Lenoir	20.5	23.5	482
Riparia Gloire	19.1	25.1	479
1202	18.8	24.3	475
St. George	11.5	25.3	291

The low rating of Rupestris St. George in this table is remarkable. The crops yielded by its grafts have averaged only about half of those of the best stocks. This stock is used much more than any other in California. It is sometimes claimed that the light bearing of vines on St. George root is due to the excessive vigor of the stock and that the crops increase with age and can be improved by longer pruning. This may be true in some cases but most of the evidence of our investigations points the other way. For most of the varieties tested and for conditions similar to those of Davis, the St. George is, as a stock, undoubtedly much inferior to several others.

C. SUMMARY AND CONCLUSIONS

The ideal of this investigation was to discover the best stock for each scion, and like all ideals is unattainable. It has made it possible to indicate certain stocks that are excellent, certain others that are fair, and certain others that are probably bad for most of our principal grape varieties, under the conditions in which they were tested in Yolo and Fresno counties. As these conditions represent the greater part of the grape-growing region of California they should be useful to grape growers who intend to plant Phylloxera-resistant vines.

In order to simplify the choice of a stock, all the available data of importance have been placed in Tables XVIII to XXXV. Each of these tables shows the behavior of a particular grape variety on each stock with which it was tested.

The data given in the columns of the tables are:

1. *Per cent in nursery:* This means the average number of first-class rooted vines obtained from one hundred bench grafts planted in the nursery. This is to indicate the probable cost of planting-material with each combination. A rate of 50 per cent may be considered a good average. Anything below 40 per cent would considerably increase the cost of the vines and below 30 per cent should not be considered at all.

2. *St. : Sc. Ratio:* This means the ratio of the diameter of the stock a few inches below the union to that of the scion a few inches above it. A ratio of 100 means that the stock and scion are equal. Ratios below 100 mean that the stock is smaller than the scion; above 100, that it is larger. Ratios of 80 to 100 may be considered excellent and normal. Ratios below 75 indicate a weakness of the vine. Ratios above 100 seem also to indicate lack of vigor.

3. *Vigor:* The numbers in the third column simply represent the comparative vigor and health of the vine as shown by its appearance.

From 80 to 100 mean perfectly satisfactory; from 70 to 80, fair; and below 70, doubtful to poor.

4. *Death Rate:* This column shows the average number of vines in a hundred which died each year during the five years after planting, not including the first. A death rate of 2 or less is normal and satisfactory; anything over 4 makes the combination doubtful.

5. *Sugar:* The figures in this column give the average Balling degrees for three years, 1915, 1916, and 1918. They are satisfactory for nearly all the combinations and usually show a tendency to be higher with the lower crops, which is a normal relation. It is only when this relation is reversed that they should be given much weight. A stock which increases the sugar as well as the crop has a double merit; a stock which gives small crops of low sugar content is doubly poor.

6. *Crop:* The figures in this column give the average crop per year per vine in pounds of grapes. For Davis they represent three years; for Kearney, six. Wherever comparable figures were obtainable, the corresponding average crops of the ungrafted vines are given after the name of the scion variety.

The varieties shown in these tables are: *five raisin grapes:* Muscat, Black Corinth, White Corinth, Sultanina (Thompson), and Sultana; *five table grapes:* Dattier de Beirut, Emperor, Cornichon, Tokay, and Malaga; *six red wine grapes:* Alicante Bouschet, Gros Mansenc, Petite Sirah, St. Macaire, Lagrain, and Valdepeñas; and *two white wine grapes:* Semillon and Palomino.

The raisin varieties include all that are used largely for drying, and the table varieties the principal grapes which are used for shipping. The wine grapes were chosen when wine making was a legal and important industry in California and include those varieties which were considered the most suitable for growing in the interior valleys when both quality and quantity were considered. Fortunately, they are very well adapted to the newer uses of wine grapes, such as drying and syrup making.

a. Best stocks for each scion variety. Table XVIII to XXXV give a summary of the record of each scion variety with each stock.

The Muscat of Alexandria is widely grown in many parts of the world and is recognized as difficult to suit in the matter of resistant stock. The stocks usually recommended for it are Lenoir, A. x R. No. 1, and Berlandieri varieties and hybrids. Lenoir should be rejected on account of its imperfect resistance. The A. x R. No. 1 has a good record at Kearney but its death rate at Davis is high. The Berlandieri hybrids 41-B and 420-A have excellent records at Davis

and are probably the best stocks to recommend, in spite of their low nursery returns. At Davis, 101–14 has an excellent record both in nursery and vineyard and is probably well suited to the Muscat in favorable situations. The high death rate at Kearney is probably due to a severe autumn frost which injured most of the vines in the second year and accounts for the higher death rate there than at Davis. St. George has a poor record in both places.

TABLE XVIII

		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
Muscat, 22.4,* on							
41-B	Davis	32	105	73	0.0	24.3	29.6
420-A	Davis	33	83	73	0.0	22.0	27.2
A. x R. No. 1	Davis	54	83	79	5.0	21.0	24.3
101–14	Davis	69	69	70	0.0	27.7	23.7
157–11	Davis	10	58	70	0.0	26.0	22.5
3309	Davis	70	79	72	0.0	25.9	22.1
3306	Davis	64	70	65	7.0	26.4	20.3
Lenoir	Davis	48	90	70	0.0	24.5	19.4
1202	Davis	56	87	62	6.4	25.9	18.4
A. x R. No. 9	Davis	65	86	50	10.2	25.3	15.1
R. Martin	Davis	....	....	70	1.9	27.3	14.4
St. George	Davis	63	....	....	....	23.0	5.7
93–5	Kearney	....	....	....	13.3	.....	20.7
St. George	Kearney	....	....	....	6.9	.....	18.6
A. x R. No. 9	Kearney	....	....	....	0.0	.....	18.2
Tok. x Rup.	Kearney	....	....	....	20.0	.....	17.9
A. x R. No. 1	Kearney	....	....	....	0.0	.....	16.0
333 E. M.	Kearney	....	....	....	0.9	.....	15.9
420-A	Kearney	....	....	....	1.8	.....	15.3
3309	Kearney	....	....	....	4.4	.....	13.2
106–8	Kearney	....	....	....	0.0	.....	10.8
101–14	Kearney	....	....	....	20.0	.....	.....

* The figures after the name of the scion variety give the average crop of the ungrafted vines at Davis during the same period.

The cause of the high death rate of grafted Muscat is supposed by some observers to be its tendency to over-bearing. The records at Davis, however, show that a high death rate is usually accompanied by poor crops and a low death rate by good crops. Over-bearing will undoubtedly intensify the effect of poor affinity but where the affinity is good the vines should not only be capable of bearing larger crops but should be longer lived if the crop is carefuly regulated by the amount of pruning.

TABLE XIX

		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
Corinth, Black, 4.8, on							
R. Gloire	Davis	61	94	Strong	0.0	29.4	12.2
41-B	Davis	48	100	....	1.5	24.5	8.3
St. George	Davis	65	97	Weak	0.0	29.9	4.5
420-A	Kearney	....	....	....	....	.....	.....
41-B	Kearney	....	....	....	0.0	.....	14.9
3306	Kearney	....	....	....	0.0	.....	11.8
R. Gloire	Kearney	....	....	....	3.3	.....	10.6

The records of 41-B, Riparia gloire, and 3306 have been the best with the Black Corinth. On St. George it has not borne well and it has refused to grow at all on 420-A, though several hundred grafts were made on different occasions. The first two crops on the best stocks were excellent, especially at Kearney, where they averaged over 20 pounds to the vine. Later crops were small, no larger than the crops of ungrafted vines without girdling. It seems probable that the union has the same effect as girdling at first, but as the vines become older it appears that even the grafted vines must be girdled. The crop of 4.8 lbs. indicated above for the ungrafted vines was obtained without girdling. Vines on St. George not only failed to bear but lacked vigor. Nursery results with other stocks were: Lenoir, 64 per cent; Tok. x Rup., 44 per cent, 106–8, 44 per cent; A. x R. No. 1, 43 per cent. The vineyard record of these stocks is not complete, but A. x R. No. 1 is promising and 41-B has done remarkably well with girdling.

TABLE XX

		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
Corinth, White, 12.5, on							
3306	Davis	53	81	80	1.4	28.0	13.1
St. George	Davis	50	97	63	1.9	29.0	6.5
R. Gloire	Davis	41	....	....	....	30.0	.....
3306	Kearney	....	....	....	0.0	.....	17.8
St. George	Kearney	....	....	....	0.0	.....	11.6
420-A	Kearney	....	....	....	20.0	.....	.....

This variety did best on 3306 and, like the Black, was a complete failure on 420-A.

TABLE XXI

		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
Sultanina, 20.7 Davis, 30.8 Kearney, on							
A. x R. No. 1	Davis	53	62	67	0.0	25.1	23.4
101–14	Davis	46	73	75	0.0	26.0	21.0
420-A	Davis	22	80	82	0.0	24.9	16.7
1202	Davis	46	75	83	0.0	25.1	16.5
R. Gloire	Davis	23	75	58	0.0	24.9	14.6
Lenoir	Davis	....	....	67	0.0	26.0	14.5
3306	Davis	47	64	87	0.0	26.4	13.9
R. Martin	Davis	80	87	58	0.0	26.1	13.2
St. George	Davis	68	76	65	0.0	27.1	11.0
Lenoir	Kearney	....	....	....	0.0	.....	56.7
1202	Kearney	....	....	....	0.0	.....	45.9
3306	Kearney	....	....	....	1.7	.....	45.7
3309	Kearney	85	....	....	0.0	.....	41.3
1616	Kearney	....	....	....	0.0	.....	39.9
101–14	Kearney	....	....	....	0.0	.....	37.4
A. x R. No. 1	Kearney	....	....	....	0.0	.....	35.9
Tok. x Rup.	Kearney	....	....	....	0.0	.....	31.6
St. George	Kearney	....	....	....	0.0	.....	30.6
R. Martin	Kearney	....	....	....	0.0	.....	30.4
A. x R. No. 9	Kearney	....	....	....	....	.....	28.3

The Sultanina is evidently well adapted to grafting on resistant stocks. Not a single vine died in five years, either at Davis or Kearney on fourteen stocks and a very small percentage on the fifteenth. The crops on eleven stocks at Kearney varied from as large as to 80 per cent larger than the crops of the ungrafted vines. At Davis, the crops on only two stocks were as large as those of the ungrafted vines. The Davis vines were somewhat stinted in the matter of water and these comparatively small crops probably indicate a greater sensitiveness to drought on the part of grafted vines.

Judging by the above records, good results may be expected with any of the stocks listed. Taking all points into consideration, perhaps the best are 3309, 1202, 101–14, and A. x R. No. 1. The last showed some defect of vigor. St. George was among the poorest, but at Kearney gave the same crop as the ungrafted vines.

TABLE XXII

		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
Sultana, 36.0, on							
A. x R. No. 1	Davis	78	82	73	1.4	21.7	42.8
41-B	Davis	49	108	73	0.0	22.2	34.7
420-A	Davis	38	100	72	0.0	23.5	32.4
101–14	Davis	65	91	70	0.0	24.2	27.1
R. Gloire	Davis	66	83	58	1.4	25.1	25.3
1202	Davis	75	100	70	1.4	24.4	23.8
3306	Davis	55	83	83	0.0	24.8	23.0
St. George	Davis	68	97	70	1.9	25.5	17.4
R. Gloire	Kearney	....	....	....	10.0	.....	71.9
41-B	Kearney	....	....	....	0.0	.....	53.1
1202	Kearney	....	....	....	8.3	.....	51.1
420-A	Kearney	....	....	....	0.0	.....	48.9
St. George	Kearney	....	....	....	0.0	.....	44.8
3306	Kearney	....	....	....	0.0	.....	41.6
101–14	Kearney	....	....	....	0.0	.....	37.8

The Sultana has borne very well on nearly all resistant stocks and the durability of the grafted vines has been excellent, with two exceptions. The records of 41-B and A. x R. No. 1 are excellent on all points. The exceptionally large crops and high death rate on R. gloire at Kearney and the signs of lack of vigor at Davis indicate that this stock is unsafe.

TABLE XXIII

		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
Dattier de Beirut, on							
93–5	Davis	....	....	73	....	24.6	19.2
41-B	Davis	....	....	90	6.2	21.9	18.5
A. x R. No. 1	Davis	29	....	82	2.7	19.3	18.2
A. x R. No. 9	Davis	49	....	75	1.4	21.0	16.8
333 E. M.	Davis	....	....	85	7.6	21.1	14.9
420-A	Davis	....	....	65	2.8	20.9	14.7
A. x R. No. 1	Kearney	....	....	....	0.0	18.0	30.6
93–5	Kearney	....	....	....	0.0	17.5	27.6
106–8	Kearney	....	....	....	2.0	19.0	10.7

From this record, the A. x R. No. 1, 93–5, and A. x R. No. 9 appear to be the best stocks. The death rate and the crop of the other stocks tested are defective.

TABLE XXIV

Emperor, 30.9, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
3306	Davis	35	86	80	0.0	18.8	37.7
A. x R. No. 1	Davis	45	76	83	2.8	18.4	36.7
3309	Davis	62	80	82	0.0	17.9	34.7
R. Gloire	Davis	65	76	77	3.3	19.2	30.1
Lenoir	Davis	35	95	83	2.8	17.7	26.0
1202	Davis	50	105	82	0.0	18.3	25.4
R. Martin	Davis	55	87	85	0.0	19.7	21.4
420-A	Davis	15	92	75	0.0	17.6	21.1
St. George	Davis	65	89	83	3.3	17.2	21.0

The Emperor, like the Cornichon, has done so well on many stocks that it is hard to choose the best. The Rip. x Rup., 3309, and 3306 have perhaps the best records. A. x R. No. 1 and Rip. gloire are also good though the latter has a rather high death rate.

The Emperor has failed on nearly all resistant stocks, according to Mr. F. T. Swett, in the Alhambra Valley in Contra Costa County, but in San Joaquin County it has done well on Rip. gloire.

TABLE XXV

Cornichon, 30.5, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
3309	Davis	35	89	67	2.8	18.7	43.1
Tok. x Rup.	Davis	....	....	....	....	18.5	42.1
3306	Davis	35	78	70	2.8	19.7	36.2
41-B	Davis	25	86	80	0.0	18.7	35.5
A. x R. No. 1	Davis	15	72	80	0.0	19.0	35.4
R. Martin	Davis	40	87	75	0.0	19.3	34.0
1202	Davis	45	97	79	5.6	19.1	32.2
A. x R. No. 9	Davis	45	88	67	11.1	18.6	31.7
St. George	Davis	45	91	77	0.0	19.1	30.5
101–14	Davis	30	84	65	0.0	19.1	29.2
R. Gloire	Davis	35	94	50	2.8	19.4	29.0
106–8	Davis	....	....	....	....	18.2	16.3

The best stock for Cornichon is difficult to choose from this table. Any of the following would probably be safe: 3309, 3306, 41-B, R. Martin, and St. George. The death rates of 3309 and 3306 are a little high while the nursery rate of 41-B is low. On the whole, R. Martin is probably the best. No stock has a very good nursery record, but all except 106–8 gave good crops. The Cornichon appears suited to most stocks though A. x R. No. 9 and 1202 are doubtful.

The record of Tokay indicates that it is a difficult variety to grow on resistant stock, judging by the high death rate on all stocks. This high death rate is at least partly due to several severe autumn frosts which killed many even of the ungrafted vines. The death rate of the

ungrafted vines was as high as the average of the grafted. For this reason, it seems safe to recommend 3309 for Tokay and also 41-B if its low nursery percentage can be improved.

TABLE XXVI

Tokay, 23.6, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
Lenoir	Davis	37	95	83	13.6	20.6	47.7
420-A	Davis	27	98	83	8.3	21.3	47.1
3309	Davis	60	80	83	5.8	21.0	40.0
41-B	Davis	22	93	83	4.2	20.8	39.8
3306	Davis	42	82	83	4.6	20.9	36.3
R. Gloire	Davis	55	78	70	7.0	22.0	22.2
St. George	Davis	50	94	73	3.0	22.0	18.5
1202	Davis	38	....	....	17.0	18.5	12.5

TABLE XXVII

Malaga, 39.6, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
41-B	Davis	5	88	83	0.0	21.3	41.6
420-A	Davis	15	89	67	0.0	21.4	41.1
R. Gloire	Davis	27	70	65	7.6	22.5	37.9
3309	Davis	28	81	83	0.0	23.1	36.9
3306	Davis	40	73	72	1.4	22.6	28.3
Lenoir	Davis	30	95	67	0.0	24.3	28.3
St. George	Davis	42	91	75	0.0	22.6	20.9
1202	Davis	30	96	83	1.5	22.6	18.9

The nursery record of this variety with all stocks is poor or only fair. The vineyard records of 41-B, 420-A, and 3309 are excellent. The record of 3306 is fair to good in both nursery and vineyard.

TABLE XXVIII

		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
Alicante Bouschet, 28.3, on							
1202	Davis	63	76	82	6.1	21.9	39.6
420-A	Davis	45	69	82	3.0	21.2	36.5
41-B	Davis	50	81	85	2.1	21.6	35.5
R. Gloire	Davis	45	67	65	7.5	23.3	27.9
3309	Davis	50	72	65	4.8	22.5	27.1
3306	Davis	37	74	67	5.0	22.6	21.7
St. George	Davis	75	79	73	6.0	23.1	15.1
Lenoir	Davis	75	....	....	....	.....	.....

This variety has the reputation of being unreliable when grafted on resistant stock and our experiences at Davis indicate that it deserves its reputation. The best stocks have been 41-B and 420-A. All the others are doubtful, owing to their high death rate. 41-B shows an excellent record in all respects and can be recommended.

The variety grown under the name of Petite Sirah in California and to which the tests of Table XXIX refer does not appear to be the real Petite Sirah of the Rhone Valley. According to L. O. Bonnet, it is the Duriff, a heavier-bearing variety from the same region. The best record is that of 3306, which is excellent in all points.

TABLE XXIX

Petite Sirah, 36.0, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
3306	Davis	70	84	82	0.0	24.2	33.9
41-B	Davis	20	93	65	0.0	23.8	32.5
R. Gloire	Davis	60	89	65	1.4	25.1	29.9
420-A	Davis	35	100	75	0.0	23.5	29.6
Lenoir	Davis	50	....	75	2.8	24.4	28.1
1202	Davis	78	95	84	4.2	23.7	27.1
3309	Davis	68	77	63	0.0	24.3	25.9
St. George	Davis	65	103	73	0.0	24.8	17.9

TABLE XXX

Gros Manseno, 20.4, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
41-B	Davis	42	100	80	4.2	24.7	12.4
1202	Davis	45	89	89	0.0	26.5	11.8
3309	Davis	23	90	67	0.0	25.4	9.2
3306	Davis	35	....	....	17.0	24.2	7.8
420-A	Davis	35	96	80	3.0	23.9	7.3
Lenoir	Davis	56	104	58	2.8	25.5	5.0
R. Gloire	Davis	95	83	57	0.0	26.7	4.8
St. George	Davis	50	104	57	7.0	26.1	4.3

The crops of Gros Mansenc on all stocks were much less than on the ungrafted vines. The safest stock appears to be 1202.

TABLE XXXI

St. Macaire, 23.6, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
420-A	Davis	22	100	83	0.0	23.5	27.0
3306	Davis	70	83	83	6.3	24.3	25.8
41-B	Davis	55	111	67	0.0	22.9	21.6
3309	Davis	48	96	79	0.0	25.1	20.7
1202	Davis	75	107	82	0.0	23.7	19.4
R. Gloire	Davis	77	88	62	0.0	25.0	18.0
St. George	Davis	67	97	67	1.7	24.6	6.2

The best records with St. Macaire are those of 41-B and 3309, though their crops were not quite equal to those of 420-A and 3306. The nursery rate of 420-A is very low and the death rate of 3306 high.

TABLE XXXII

Lagrain, 19.6, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
41-B	Davis	30	94	83	0.0	24.1	22.2
3309	Davis	60	81	75	0.0	25.6	14.5
1202	Davis	65	106	87	0.0	24.9	13.0
R. Gloire	Davis	42	88	58	1.9	24.5	11.8
3306	Davis	62	81	70	1.9	24.6	10.9
420-A	Davis	40	97	75	1.7	24.5	10.0
Lenoir	Davis	27	103	67	0.0	24.0	8.1
St. George	Davis	70	97	65	0.0	25.4	6.5

The only stock which has given satisfactory crops with Lagrain is 41-B whose record is excellent in all respects except the nursery percentage, which is low. Grafts on 3309 and 1202 are the second choice. They have given good returns in the nursery but have borne less than the ungrafted vines.

TABLE XXXIII

Valdepeñas, 32.7, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
420-A	Davis	60	94	79	7.1	24.4	25.0
41-B	Davis	65	81	80	4.2	25.1	19.1
Lenoir	Davis	82	87	82	4.2	25.4	18.3
1202	Davis	65	90	87	5.7	25.2	17.9
3309	Davis	88	82	72	2.0	26.3	17.8
3306	Davis	65	80	82	3.0	26.1	14.7
R. Gloire	Davis	75	80	72	0.0	26.3	10.5
St. George	Davis	75	91	82	4.5	26.9	8.0

This variety is remarkable for its high nursery per cent and its high death rate. Success in the nursery does not necessarily mean success in the vineyard. Only the R. gloire has a low death rate but its crops are poor. The best record is perhaps that of 41-B or that of 3309.

TABLE XXXIV

Semillon, 22.2, on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
3309	Davis	75	78	79	0.0	26.1	17.5
420-A	Davis	47	95	87	1.4	23.7	16.8
3306	Davis	35	83	79	0.0	26.0	15.3
1202	Davis	23	90	83	0.0	26.1	12.8
R. Gloire	Davis	50	74	67	1.4	25.9	12.6
41-B	Davis	17	....	....	0.0	25.3	10.5
St. George	Davis	47	84	72	0.0	25.6	6.7

The crops of Semillon have been lower on all stocks than on its own roots. The best stocks have been 3309 and 420-A.

TABLE XXXV

Palomino, 36.0 on		Nursery %	St. : Sc.	Vigor	Death rate	Sugar	Crop
420-A	Davis	15	84	82	3.3	24.2	55.2
3309	Davis	50	76	87	1.4	25.5	34.2
3306	Davis	40	70	82	0.0	25.4	29.3
41-B	Davis	22	88	80	0.0	24.3	22.8
R. Gloire	Davis	50	93	82	1.9	25.3	15.1
1202	Davis	65	105	83	0.0	24.2	14.9
St. George	Davis	72	88	87	0.0	25.5	10.6

The Palomino is one of the most robust and fruitful vines grown and on some of the stocks it retains these characteristics. It has been exceptionally fruitful on 420-A, but unfortunately its nursery record is very low on this stock. Its death rate also is somewhat high so that this combination is doubtful. The safest stocks seem to be 3309 and 3306.

Table XXXVI shows the three stocks which can be recommended for each variety on the basis of the data available. The list includes twelve stocks, but five of them occur only once, and one of them only twice. Another, 1202, occurs three times, but with one exception only as a second or third choice. It is possible, therefore, to reduce the stocks recommended for the eighteen varieties given to four, as follows:

Chasselas x Berlandieri 41-B for Muscat, Black Corinth, Sultana, Cornichon, Tokay, Alicante Bouschet, Gross Mansenc, and St. Macaire.

Riparia x Rupestris 3309 for Sultanina (Thompson), Emperor, Malaga, Lagrain, Valdepeñas, Semillon, and Palomino.

Riparia x Rupestris 3306 for White Corinth and Petite Sirah (Duriff).

Aramon x Rupestris No. 1 for Dattier de Beirut.

TABLE XXXVI

STOCKS RECOMMENDED FOR EACH SCION VARIETY

	First	Second	Third
Muscat	41-B	420-A	101–14
Corinth, Black	41-B	R. Gloire	A. x R. No. 1
Corinth, White	3306	St. George	.....
Sultanina	3309	1202	A. x R. No. 1
Sultana	41-B	A. x R. No. 1	420-A
Dattier de Beirut	A. x R. No. 9	A. x R. No. 1	93–5
Emperor	3309	3306	A. x R. No. 1
Cornichon	R. Martin	St. George	41-B
Tokay	41-B	3309	.....
Malaga	3309	3306	420-A
Alicante Bouschet	41-B	420-A	.....
Gros Mansenc	1202	41-B	.....
Petite Sirah (Duriff)	3306	420-A	41-B
St. Macaire	41-B	3309	420-A
Lagrain	3309	41-B	1202
Valdepeñas	3309	41-B	.....
Semillon	3309	420-A	3306
Palomino	3309	3306	41-B

These summaries indicate that three varieties of resistant stock will supply the needs of all our common varieties of raisin and table grapes (Dattier is still little grown).

(*b*) Best stocks for general use: As many other varieties are grown on a smaller scale, it is desirable to know what stock is most likely to give good results with a variety on which we have no data. Figure 11 has been prepared for this purpose.

This figure represents the comparative results obtained with the seven principal stocks in the most important matters, i.e., crop, durability in the vineyard, and the percentage of No. 1 grafts obtained in the nursery. The record of each stock is given with each of the same ten scion varieties.

The black blocks represent the total returns for each stock with the ten scions. Each step in a block represents the return of a stock with a single scion variety. The black areas therefore represent the average standing of each stock and the steps the amount of variation.

This figure shows that the best stocks, if we consider all three bases of comparison, in regard to their degree and their regularity, are 3309, 3306, and Rip. gloire. The well-proved unreliability of the

last stock when planted on any but the best soil abundantly supplied with water should incline us to reject it in favor of one of the others in most instances.

The largest average crops were produced on 420-A and 41-B, but their low nursery returns are a great defect. That this is not a vital objection, however, can be shown by comparing their record with that of Rup. St. George. While only a little more than half the percentage of bench grafts were obtained in the nursery with these stocks as with St. George, they produced more than twice as much crop in

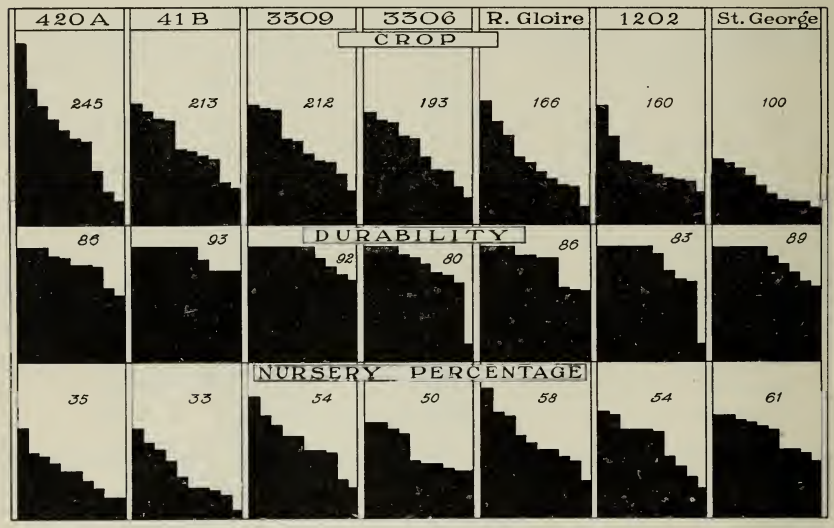

Fig. 11.—Record of seven principal stocks with ten scions.

the vineyard. Therefore, even though the grafted vines for planting cost twice as much, they would be much more profitable to plant, for if only half the number were planted they would cost no more and would produce a larger crop.

It is very probable that with experience a skillful nurseryman could improve on our methods and increase the nursery percentage. If this were done, these stocks, especially 41-B, would probably be the best stocks for general use that one could choose.

In the meanwhile, Rip. x Rup. 3309 and Rip. x Rup. 3306 can be highly recommended as excellent stocks for general purposes for the San Joaquin and Sacramento Valley vineyards and there is strong evidence that Rupestris St. George should be abandoned in their favor. Mourvèdre x Rup. 1202 seems to be only a little better than St. George.

TABLE X

DURABILITY OF GRAFTED VINES

(All combinations, Davis)

Combination	Planted 1911	Growing 1912 Stand	Growing 1917	Death rate, loss per cent per annum
Alicante Bouschet on				
41-B	12	8	7	2.1
420-A	12	11	9	3.0
3309	10	7	5	4.8
3306	12	10	7	5.0
St. George	17	11	7	6.0
1202	23	22	14	6.1
Riparia Gloire	24	20	11	7.5
Totals and mean %	110	89	60	
Alicante Ganzin on				
St. George	5	4	2	8.3
Beba on				
Lenoir	11	11	9	3.0
Riparia Gloire	23	22	14	6.0
3309	12	12	7	7.0
3306	7	7	4	7.1
41-B	6	6	3	8.3
1202	11	10	3	11.7
Totals and mean %	70	68	40	
Black Corinth on				
Riparia Gloire	14	13	13	0.0
St. George	9	8	8	0.0
41-B	24	22	20	1.5
Totals and mean %	47	43	41	
White Corinth on				
3306	12	12	11	1.4
St. George	12	9	8	1.9
Totals and mean %	24	21	19	
Cornichon on				
St. George	6	6	6	0.0
R. Martin	6	3	3	0.0
101–14	5	5	5	0.0
A. x R. No. 1	3	3	3	0.0
41.B	5	5	5	0.0
Riparia Gloire	6	6	5	2.8
3309	6	6	5	2.8
3306	6	6	5	2.8
1202	6	6	4	5.6
A. x R. No. 9	6	6	2	11.1
Totals and mean %	55	52	43	
Dattier de Beirut on				
A. x R. No. 9	24	24	22	1.4
A. x R. No. 1	48	43	36	2.7
420-A	12	12	10	2.8
41-B	12	10	9	6.2
333 E. M.	12	11	6	7.6
Totals and mean %	108	100	83	

TABLE X—(*Continued*)

Combination	Planted 1911	Growing 1912 Stand	Growing 1917	Death rate, loss per cent per annum
Emperor on				
R. Martin	11	9	9	0.0
3309	9	8	8	0.0
1202	8	8	8	0.0
3306	4	4	4	0.0
420-A	3	3	3	0.0
Lenoir	6	6	5	2.8
A. x R. No. 1	8	6	5	2.8
St. George	10	10	8	3.3
Riparia Gloire	7	5	4	3.3
Totals and mean %	66	59	54	
Lagrain on				
St. George	12	5	5	0.0
1202	12	10	10	0.0
3309	12	9	9	0.0
41-B	12	9	9	0.0
Lenoir	10	8	8	0.0
420-A	12	11	10	1.7
Riparia Gloire	12	9	8	1.9
3306	12	9	8	1.9
Totals and mean %	94	70	67	
Malaga on				
St. George	12	12	12	0.0
Lenoir	12	12	12	0.0
3309	8	5	5	0.0
41-B	2	2	2	0.0
420-A	6	6	6	0.0
3306	12	12	11	1.4
1202	11	11	10	1.5
Riparia Gloire	11	11	6	7.6
Totals and mean %	74	71	64	
St. Macaire on				
Riparia Gloire	24	14	14	0.0
1202	24	17	17	0.0
3309	7	6	6	0.0
420-A	8	7	7	0.0
41-B	16	9	9	0.0
St. George	22	10	9	1.7
3306	17	8	5	6.3
Totals and mean %	118	71	67	
Muscat on				
420-A	12	12	12	0.0
41-B	24	24	24	0.0
Lenoir	6	6	6	0.0
157–11	2	2	2	0.0
101–14	24	20	20	0.0
3309	11	8	8	0.0
R. Martin	9	9	8	1.9
1202	13	13	8	6.4
A. x R. No. 9	13	13	5	10.2
3306	24	24	14	7.0
A. x R. No. 1	11	10	7	5.0
St. George	4	2	....	....
Totals and mean %	153	143	114	

TABLE X—(*Continued*)

Combination	Planted 1911	Growing 1912 Stand	Growing 1917	Death rate, loss per cent per annum
Flame Muscat on				
St. George	24	13	11	2.6
Gros Mansenc on				
Riparia Gloire	24	4	4	0.0
1202	14	13	13	0.0
St. George	15	8	7	2.1
Lenoir	12	12	10	2.8
420-A	12	11	9	3.0
41-B	12	4	3	4.2
3306	9	1	0	17.0
3309	8	5	5	0.0
Totals and mean %	106	58	51	
Palomino on				
St. George	17	13	13	0.0
1202	10	10	10	0.0
3306	12	12	12	0.0
41-B	7	7	7	0.0
3309	16	12	11	1.4
Riparia Gloire	10	9	8	1.9
420-A	5	5	4	3.3
Totals and mean %	77	68	65	
Pierce on				
St. George	11	11	11	0.0
Semillon on				
1202	6	3	3	0.0
3306	11	7	7	0.0
St. George	12	10	10	0.0
3309	24	19	19	0.0
420-A	12	12	11	1.4
Riparia Gloire	12	12	11	1.4
Lenoir	11	10	....	....
Totals and mean %	88	73	61	
Petite Sirah on				
3309	12	12	12	0.0
3306	12	11	11	0.0
420-A	12	12	12	0.0
41-B	8	8	8	0.0
St. George	16	14	14	0.0
Riparia Gloire	12	12	11	1.4
Lenoir	12	12	10	2.8
1202	12	12	9	4.2
Totals and mean %	96	93	87	
Sultana on				
3306	12	12	12	0.0
41-B	17	17	17	0.0
101–14	12	11	11	0.0
420-A	7	6	6	0.0
A. x R. No. 1	12	12	11	1.4
1202	12	12	11	1.4
Riparia Gloire	12	12	11	1.4
St. George	12	9	8	1.9
Totals and mean %	96	91	87	

TABLE X—(*Concluded*)

Combination	Planted 1911	Growing 1912 Stand	Growing 1917	Death rate, loss per cent per annum
Sultanina on				
101–14	12	12	12	0.0
A. x R. No. 1	12	12	12	0.0
420-A	8	8	8	0.0
Lenoir	8	8	8	0.0
R. Martin	8	8	8	0.0
1202	12	11	11	0.0
3306	12	11	11	0.0
St. George	12	10	10	0.0
Riparia Gloire	3	2	2	0.0
Totals and mean %	87	82	82	
Tokay on				
St. George	12	11	9	3.0
41-B	8	8	6	4.2
3306	12	11	8	4.6
3309	24	23	17	5.8
Riparia Gloire	12	12	7	7.0
420-A	8	8	4	8.3
Lenoir	12	11	2	13.6
1202	8	8	0	17.0
Totals and mean %	96	92	53	
Valdepeñas on				
Riparia Gloire	24	14	14	0.0
3309	24	17	15	2.0
3306	24	22	18	3.0
Lenoir	24	12	9	4.2
41-B	16	12	9	4.2
St. George	24	22	16	4.5
1202	24	23	14	5.7
420-A	8	7	4	7.1
Totals and mean %	168	129	99	

TABLE XI

DURABILITY OF GRAFTED VINES

(Kearney Experiment Vineyard)

Combination	Vines planted 1912–1913	Vines growing 1916–1917	Death rate loss per cent per annum
Black Corinth on			
41-B	5	5	0.0
3306	3	3	0.0
Riparia Gloire	6	5	3.3
White Corinth on			
St. George	1	1	0.0
3306	13	13	0.0
420-A	3	0	20.0
Dattier de Beirut on			
93–5	11	11	0.0
A. x R. No. 1	6	6	0.0
106–8	37	34	2.0
Sultana on			
101–14	3	3	0.0
St. George	10	10	0.0
3306	8	8	0.0
420-A	14	14	0.0
1202	12	7	8.3
Riparia Gloire	2	1	10.0
41-B	20	20	0.0
Sultanina on			
1616	2	2	0.0
R. Martin	7	7	0.0
3309	5	5	0.0
Lenoir	6	6	0.0
Tokay x Rupestris	8	8	0.0
A. x R. No. 1	3	3	0.0
St. George	14	14	0.0
101–14	17	17	0.0
1202	10	10	0.0
3306	14	13	1.7
Muscat on			
A. x R. No. 1	10	10	0.0
106-8	6	6	0.0
333 E. M.	22	21	0.9
420-A	33	30	1.8
3309	32	25	4.4
St. George	84	55	6.9
93–5	6	2	13.3
A. x R. No. 9	6	2	13.3
Tokay x Rupestris	6	0	20.0
101–14	3	0	20.0

TABLE XII

CROPS OF VARIOUS VARIETIES ON VARIOUS STOCKS
Experiment Vineyard, Davis, Calif.

Variety	Pounds per vine* 1914	1915	1916	1917	Mean, 1915–1917 Pounds	Balling
Alicante Bouschet	*16.02*	*17.70*	*46.05*	*21.17*	*28.31*	.....
1202	15.75	18.79	49.34	50.78	39.64	22.3
420-A	12.86	21.90	38.13	49.38	36.47	21.6
41-B	10.82	14.00	46.71	45.68	35.46	21.9
Riparia Gloire	8.98	16.23	34.00	33.52	27.92	23.9
3309	14.20	14.80	30.00	36.45	27.08	21.9
3306	7.79	9.63	21.14	34.22	21.66	23.5
St. George	7.91	8.38	9.15	27.75	15.09	22.9
Alicante Ganzin	.....	.....	.....	.....	.....	.....
St. George	.....	.....	5.13	.....	5.13	22.0
Corinth, Black	*4.82*	.....	.....	.....	*4.82*	.....
Riparia Gloire	.....	2.69	16.88	17.00	12.19	30.4
41-B	.....	1.40	13.14	10.48	8.34	26.0
St. George	.....	.....	4.56	4.44	4.50	31.1
Corinth, White	*8.30*	*5.51*	*18.18*	*13.80*	*12.50*	.....
3306	.....	1.92	27.38	10.08	13.13	27.7
St. George	.....	.63	12.20	6.60	6.48	29.8
Cornichon	*6.75*	*13.46*	*50.22*	*27.95*	*30.54*	.....
3309	.....	19.60	68.80	40.75	43.05	18.2
Tok. x Rup.	.....	.....	37.00	47.25	42.13	18.3
3306	.....	21.60	52.42	34.42	36.15	17.9
41-B	.....	18.40	62.20	25.85	35.48	17.8
A. x R. G. No. 1	.....	15.00	55.25	36.08	35.44	18.3
R. Martin	.....	8.33	54.50	39.17	34.00	18.7
1202	.....	10.83	53.60	32.17	32.20	18.3
A. x R. G. No. 9	.....	9.67	55.06	30.50	31.74	18.0
St. George	.....	4.67	55.29	31.50	30.49	18.7
101–14	.....	6.20	52.42	28.88	29.17	17.9
R. Gloire	.....	12.60	45.71	28.67	28.99	18.6
106–8	.....	.....	16.25	.....	16.25	17.5
Dattier de Beyreuth	.....	.....	.....	.....	.....	.....
93–5	3.44	13.94	29.71	13.88	19.18	22.7
41-B	1.43	8.90	23.77	22.70	18.46	21.6
A. x R. G. No. 1	2.09	14.92	27.51	12.20	18.21	22.6
A. x R. G. No. 9	2.06	13.14	26.32	10.92	16.79	21.8
333 E. M.	.83	7.67	27.04	10.00	14.90	20.0
420-A	.80	10.60	20.45	12.91	14.65	22.0
Emperor	*6.54*	*21.11*	*40.28*	*31.31*	*30.90*	.....
3306	.....	10.75	59.25	43.19	37.73	19.7
A. x R. G. No. 1	.....	10.25	65.75	34.20	36.73	18.6
3309	.....	7.50	48.03	48.66	34.73	18.9
R. Gloire	.....	3.80	54.30	32.15	30.08	20.3
Lenoir	.....	4.14	54.83	19.13	26.03	17.9
1202	.....	3.00	42.63	30.63	25.42	17.8
R. Martin	.....	1.67	41.58	20.90	21.38	19.5
420-A	.....	5.00	31.97	26.26	21.08	17.7
St. George	.....	2.13	38.73	22.00	20.95	19.0
Gros Mansenc	*5.21*	*22.86*	*21.10*	*17.36*	*20.44*	.....
41.B	1.92	5.33	16.08	15.67	12.36	25.7
1202	4.37	3.85	17.15	14.23	11.78	26.5
3309	3.15	1.00	16.40	10.05	9.15	25.8
3306	.....	.....	8.75	6.75	7.75	26.5
420-A	1.18	2.11	10.13	9.56	7.27	27.2
Lenoir	.67	2.67	6.35	5.91	4.98	26.2
Riparia Gloire	1.44	2.67	7.48	4.27	4.81	26.4
St. George	1.33	5.00	4.21	3.56	4.26	26.6

* The figures in italics opposite the name of each scion variety give the average crops of the ungrafted vines.

TABLE XII—(*Continued*)

Variety	Pounds per vine				Mean, 1915–1917	
	1914	1915	1916	1917	Pounds	Balling
Lagrain	*10.96*	*16.06*	*24.48*	*18.22*	*19.59*	.....
41-B	3.31	9.78	36.33	20.44	22.18	24.5
3309	3.06	7.50	17.22	18.83	14.52	26.6
1202	4.33	5.64	12.06	21.33	13.01	25.0
Riparia Gloire	2.59	7.67	11.75	15.90	11.77	25.7
3306	1.56	6.63	11.33	14.80	10.92	25.7
420-A	2.50	4.90	10.48	14.67	10.02	24.0
Lenoir	.54	3.57	7.97	12.69	8.08	24.2
St. George	2.20	3.60	7.96	8.00	6.52	26.4
Malaga	*15.39*	*22.08*	*57.64*	*39.14*	*39.62*	.....
41-B	22.00	29.50	54.75	40.50	41.58	20.3
420-A	13.16	41.33	56.38	25.58	41.10	20.8
Riparia Gloire	12.71	33.00	43.82	36.88	37.90	23.0
3309	21.20	30.40	53.90	26.50	36.93	22.9
3306	7.25	20.75	39.54	24.67	28.32	22.9
Lenoir	8.63	25.08	39.67	20.15	28.30	21.3
St. George	4.46	12.17	37.71	12.83	20.90	23.0
1202	11.45	15.50	25.40	15.83	18.91	22.7
Muscat, Flame	.....	*9.16*	.....	*12.23*	*10.70*	.....
St. George	.....	.....	13.41	12.43	12.92	25.0
Muscat	.....	*19.39*	*33.43*	*14.45*	*22.42*	.....
41-B	5.10	22.11	38.33	28.38	29.61	24.0
420-A	8.04	26.58	29.63	25.23	27.15	24.6
A. x R. G. No. 1	9.38	31.50	26.31	15.14	24.32	23.2
101–14	6.68	18.65	32.58	19.93	23.72	26.3
157–11	4.13	20.00	28.50	19.13	22.54	26.1
3309	7.39	19.63	23.67	22.94	22.08	25.5
3306	6.88	21.53	20.74	18.65	20.31	26.5
Lenoir	6.42	13.33	18.17	26.55	19.35	24.1
1202	7.17	17.00	20.90	17.25	18.38	24.8
A. x R. G. No. 9	4.30	18.50	15.11	11.81	15.14	25.5
R. Martin	6.21	9.63	18.19	15.34	14.39	26.4
St. George	.....	.....	5.64	5.71	5.68	28.2
Palomino	*12.50*	*36.92*	*47.27*	*23.92*	*36.04*	.....
420-A	9.94	34.25	85.44	45.83	55.17	24.1
3309	10.45	25.00	36.00	41.56	34.19	26.0
3306	8.10	30.92	29.00	27.90	29.27	25.6
41-B	10.43	30.00	13.14	25.21	22.78	24.4
Riparia Gloire	4.41	10.75	19.47	15.03	15.08	25.8
1202	6.45	10.40	20.44	13.92	14.92	25.3
St. George	6.81	9.46	14.42	7.83	10.57	26.5
Pierce (Isabella)	.....	.....	.....	.....	.....	.....
Tck. x Rup.	.....	.....	26.92	17.17	22.05	21.7
St. George	.....	.....	17.00	13.43	15.22	21.5
St. Macaire	*11.44*	*16.89*	*33.71*	*20.07*	*23.56*	.....
420-A	4.86	16.57	36.96	27.89	27.13	24.5
3306	29.92	17.17	36.15	24.00	25.77	24.3
41-B	5.18	16.00	33.95	14.73	21.56	23.3
3309	3.83	16.00	22.04	24.04	20.69	24.4
1202	4.47	10.00	28.99	19.10	19.36	24.1
Riparia Gloire	5.20	15.25	21.46	17.15	17.95	25.4
St. George	1.53	3.54	7.89	7.14	6.19	25.5

TABLE XII—(*Concluded*)

Variety	Pounds per vine				Mean, 1915–1917	
	1914	1915	1916	1917	Pounds	Balling
Semillon	.....	*14.12*	*20.76*	*31.74*	*22.21*	.....
3309	9.83	9.32	19.87	23.29	17.49	25.9
420-A	4.48	9.17	23.14	17.94	16.75	25.5
3306	8.32	8.71	17.21	19.86	15.26	27.0
1202	4.67	9.33	19.25	9.75	12.78	26.2
Riparia Gloire	5.82	8.45	14.91	14.40	12.59	26.8
41-B	.....	.....	10.50	.....	10.50	26.9
St. George	4.70	2.50	7.80	9.85	6.72	26.4
Sirah, Pte.	.....	*30.61*	*37.70*	*39.72*	*36.01*	.....
3306	10.32	31.33	31.48	38.88	33.90	24.2
41-B	14.16	33.75	42.86	20.14	32.25	22.0
Riparia Gloire	10.27	25.09	32.80	31.71	29.87	23.5
420-A	5.85	26.25	38.17	24.35	29.59	21.9
Lenoir	8.33	21.70	40.89	21.63	28.07	22.2
1202	13.92	22.17	30.56	28.65	27.13	23.1
3309	7.81	26.92	26.92	23.94	25.93	22.0
St. George	4.15	12.35	20.83	20.56	17.91	24.8
Sultana	*21.58*	*25.33*	*36.57*	*45.94*	*35.95*	.....
A. x R. G. No. 1	.....	17.09	65.45	45.73	42.76	21.4
41-B	.....	12.65	52.35	39.06	34.69	20.6
420-A	.....	8.67	55.46	33.00	32.38	22.5
101–14	.....	7.27	45.15	28.83	27.08	22.4
Riparia Gloire	.....	1.14	41.83	32.92	25.30	23.2
1202	.....	5.33	36.36	29.82	23.84	22.3
3306	.....	7.83	32.02	29.25	23.03	23.2
St. George	.....	10.36	20.00	21.80	17.39	22.5
Sultanina	.....	*13.50*	*30.35*	*18.32*	*20.72*	.....
A. x R. G. No. 1	.....	6.83	46.67	16.58	23.36	24.2
101–14	.....	8.50	44.38	10.17	21.02	24.2
420-A	.....	3.75	35.69	10.50	16.65	25.0
1202	.....	3.18	35.89	10.45	16.51	25.1
Riparia Gloire	.....	5.29	29.39	9.14	14.61	26.4
Lenoir	.....	4.63	34.22	4.75	14.53	24.6
3306	.....	4.00	28.46	9.17	13.88	25.3
R. Martin	.....	1.00	30.84	7.63	13.16	24.5
St. George	.....	.60	24.75	7.75	11.03	25.7
Tokay	.....	*15.27*	*23.58*	*32.00*	*23.62*	.....
Lenoir	7.38	52.50	47.00	43.50	47.67	21.1
420-A	15.63	43.75	46.06	51.33	47.05	20.5
3309	14.56	33.41	45.85	40.76	40.01	21.6
41-B	16.46	47.50	41.75	30.18	39.81	21.2
3306	10.94	33.13	40.00	35.88	36.34	22.0
Riparia Gloire	11.67	24.75	20.82	20.98	22.18	23.0
St. George	7.09	18.88	28.23	8.25	18.45	21.6
1202	.....	5.50	12.00	19.29	12.26	21.5
Valdepeñas	*12.97*	*19.14*	*44.75*	*34.09*	*32.66*	.....
420-A	10.25	20.50	28.50	26.06	25.02	25.6
41-B	5.78	10.20	23.10	23.88	19.06	26.1
Lenoir	5.15	12.20	21.30	21.33	18.28	26.2
1202	8.63	11.57	20.84	21.29	17.90	26.4
3309	8.14	8.40	23.97	21.08	17.82	26.7
3306	8.71	9.00	19.18	16.01	14.73	27.2
Riparia Gloire	11.54	13.57	8.83	9.06	10.49	27.3
St. George	8.35	27.72	14.32	7.00	8.01	28.8

TABLE XIII

CROP OF RAISIN VARIETIES ON VARIOUS STOCKS

Experiment Vineyard, Kearney, California

Variety and stock	Pounds of grapes per vine						Mean, 1914-1919
	1914	1915	1916	1917	1918	1919	
Muscat (1)	*15.6*	*21.1*	*24.9*	*14.5*	*15.9*	*20.4*	*18.7*
93–5	20.9	28.7	35.0	10.1	20.5	8.7	20.7
A. x R. No. 1	17.5	22.6	37.1	9.6	11.7	10.9	18.2
St. George	14.3	16.5	25.1	16.8	14.7	8.7	16.0
A. x R. No. 9	11.8	8.8	34.8	17.0	24.5	14.5	18.6
333 E. M.	9.8	20.4	26.6	13.6	15.3	9.5	15.9
420-A	10.6	16.7	26.8	14.6	13.9	8.8	15.3
3309	9.4	21.5	24.9	9.5	9.3	4.8	13.2
106–8	8.0	19.8	18.7	11.4	4.0	2.8	10.8
101–14	.....	.....	5.6	.....	.....	.....	.....
Tok. x Rup.	.....	.....	.....	.....	10.0	14.0	.....
Means grafted	12.8	19.4	28.5	12.6	13.4	8.2	16.1
Sultanina (2)	.....	.....	.....	.....	*39.1*	*32.0*	.....
Lenoir	.....	53.5	81.1	59.8	41.0	48.0	56.7
1202	36.1	49.5	51.2	58.7	41.0	38.0	45.9
3306	22.4	37.1	83.0	49.3	39.0	43.0	45.7
3309	.....	35.0	54.6	39.2	56.0	22.0	41.3
1616	.....	10.5	68.5	46.3	45.0	29.0	39.9
A. x R. No. 9	.....	.....	38.8	.....	.....	.....	.....
101–14	28.4	30.3	60.4	34.3	41.0	30.0	37.4
Tok. x Rup.	.....	32.0	42.6	25.5	25.0	27.0	31.6
St. George	25.3	25.5	49.3	32.6	27.0	23.0	30.6
R. Martin	.....	26.9	27.2	39.7	41.0	17.0	30.4
A. x R. No. 1	.....	4.5	38.8	42.3	40.0	54.0	35.9
Means grafted	28.1	30.5	54.1	42.8	39.7	33.1	39.5
Sultana	.....	.....	.....	.....	*21.2*	*18.0*	.....
Riparia Gloire	.....	75.5(3)	95.5	70.0	54.0	65.0	71.9
41-B	.....	58.9	59.3	68.2	51.0	28.0	53.1
420-A	.....	55.2	66.0	59.3	42.0	22.0	48.9
1202	.....	41.8	70.9	46.5	71.0	25.0	51.1
St. George	.....	39.9	61.8	51.1	51.0	20.3	44.8
3306	.....	45.9	47.5	48.5	51.0	15.0	41.6
101–14	.....	52.8(3)	68.0	12.3	42.0	14.0	37.8
Means grafted	.....	52.9	67.0	50.8	51.7	27.0	49.9
							'15-'19
Corinth, Black	.....	.....	.....	*7.9*	*17.8*	.....	12.9
41-B	.....	6.2	22.6	20.7	15.7	9.1	14.9
3306	.....	7.0	22.5	14.3	11.3	3.9	11.8
Riparia Gloire	.....	1.0	20.5	11.0	.....	10.0	10.6
Means grafted	.....	4.7	21.9	15.3	13.5	7.7	.....
Corinth, White	.....	.....	.....	*5.0*	.....	.....	.....
3306	.....	8.0	29.8	20.3	.....	.....	17.8
St. George	.....	3.0	31.5	10.8	.....	.....	11.6
Means grafted	.....	5.5	30.7	15.6	.....	.....	.....

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